UNIV. OF MICH.
SEP 20 1907

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1655

Entered at the Post Office of New York, N. Y., as Second Class Matter.
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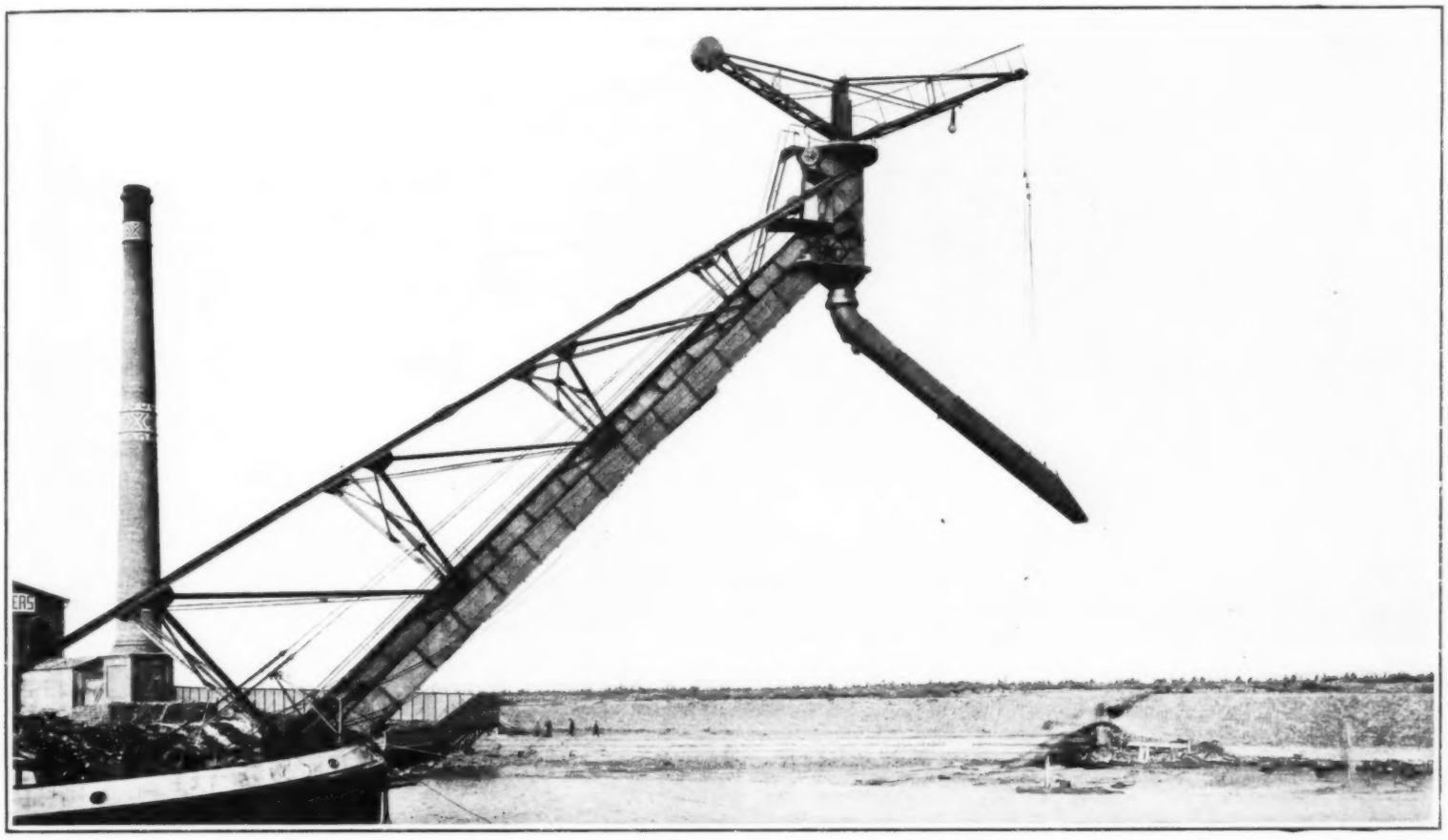
Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXIV., No. 1655.

NEW YORK, SEPTEMBER 21, 1907.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



THE BOW OF THE VESSEL, SHOWING THE ELEVATOR WHICH CARRIES THE COAL AND THE CHUTE WHICH DELIVERS IT INTO THE SHIP'S BUNKERS.

COAL IS AUTOMATICALLY DELIVERED FROM THE COALING VESSEL INTO THE BUNKERS OF THE SHIP.

A SELF-PROPELLING COALING VESSEL.

SELF-PROPELLING COALING VESSEL.

WITH AUTOMATIC SELF-REGISTERING WEIGHING MACHINE.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

AN interesting type of plant for coaling steamships, one possessing several novel features including a self-registering automatic weighing machine to record the quantity delivered, has been acquired recently by the Coal Trading Association of Rotterdam. This installation, which is illustrated in the accompanying photographs, was designed and constructed by Werf Custo Firma A. F. Smulders, of Schiedam, Holland, to whose courtesy we are indebted for the accompanying particulars.

The general design of the apparatus can be gathered from the illustrations. It comprises a lighter or barge containing the coal, with a carrier at the bow up which the coal conveyers travel, dumping their contents through a chute direct into the vessel's bunkers. The coaling barge is divided into ten compartments, the capacity of each of which is 60 tons, representing a total of 600 tons for the whole craft, though when loaded with a good head 700 tons can be carried. Each of these compartments is again subdivided into 10-ton bins. Extending the whole length of the hold in a tunnel beneath the compartments, above the vessel's keel, runs an endless conveyer or bucket chain, passing out at the bow on to the ladder, elevator fashion. On the summit of this ladder is pivoted a receiver, into which the coal contained in the conveyer buckets is emptied as they pass over the end, the falling coal thence passing through the chute into the ship's bunkers. The coal gravitates through sliding doors into the conveyer buckets as they pass beneath the coal compartments of the hold, the compartments being emptied one at a time. Before reaching the bend in the tunnel to ascend the carrier the buckets pass over the automatic self-registering weighing machine; a record of the weight of the load thus being obtained. The carrier can be raised and lowered as required according to the height of the ship to be coaled, and the chute is attached to the receiver at its head by means of a universal joint, so that when once the coaling barge is moored alongside, the various bunkers of the ship can be reached with little and easy manipulation. The conveyer itself is driven by either one of the two engines by which the barge is propelled. These engines are of the compound type fed by a Scotch boiler, and drive twin screws.

The weighing machine is of the Blake-Denison type, which is officially recognized by the British Board of Trade. In action a number of buckets are accepted on the platform and weighed together, and the machine is guaranteed to weigh accurately within one per cent of the actual load, even when the vessel lies at an angle of 10 deg. either fore, aft, or athwartship. In actual test, when a much greater angle was imposed, the accuracy was found to be in no way affected. By means of this self-registering machine the weight of coal delivered can be instantly read off when desired.

This particular coaling barge was designed for a delivery capacity of 100 tons per hour with its ladder at an angle of 45 deg. and the axle of the upper tumbler 59 feet above water level, but in actual practice this output has been considerably exceeded, a delivery of 140 tons per hour being easily attained.

In the design of this apparatus especial care has been devoted to the handling of the coal, so that it may not be broken during the transfer from the barge to the ship's bunkers, while at the same time, owing to the shape of the buckets of the conveyer, which has the appearance of a vertebrated belt, there is no loss whatever of the contents during conveyance. Coaling operations do not interfere with the loading or unloading of freight, and owing to the coal being delivered directly into the bunkers there is an entire absence of dust. Owing to the success of this barge, the Coal Trading Association of Rotterdam has since acquired a second craft of this type.

THE DEVELOPMENT OF ARMORED WAR VESSELS.—IV.

ARMOR PLATING IN THE UNITED STATES

BY J. H. MORRISON.

Continued from Supplement No. 1654, page 171.

JUST before the report of the board of army and navy officers was made of the artillery experiments on the iron target, Robert L. Stevens on January 25, 1842, gave a description of the projected iron war vessel, that it will be noticed is very general in its details.

General Description of a Steam Battery or Vessel of War Proposed to be Built for the Government of the United States by Robert L. Stevens for the Defence of the Harbor of New York.

The steam battery or vessel referred to is to be constructed upon a plan entirely new, invented by the writer, and is to be shot and shell proof. She is to have greater speed than any vessel of war now afloat. The engines and propelling apparatus to be so placed that the latter shall be submerged, and the whole engine out of the way of shot from the vessel of an enemy. Her guns are to be large, and adapted to shot and shell. Her burden not less than 1,500 tons.

The practicability of rendering such a vessel proof against shots and shells is not a theoretical assumption, but has been proved by the test of positive experiments. These experiments were recently made at Sandy Hook under the superintendence of John C. and Edwin A. Stevens, and in the presence of a joint board of army and navy officers appointed by the government. From their result, no doubt whatever remains of the fact that a series of wrought-iron boiler plates riveted together, and placed upon each other until the strata amount to 4½ inches in thickness, will effectually resist the force of a 64-pound shot when fired with battering charges at the distance of 30 yards. Fifteen or twenty shots were also fired at this distance, and from guns of different calibers, against a target thus constructed, and were made to strike against it within a space of about 2 feet by 4 feet; and these produced so little effect as to leave it in a fit state to protect anything in its rear against a similar force. Shells fired from the same distance scarcely indented the iron, and both shots and shells were invariably broken into small fragments.

The above-named experiments were tried under the supervision of the officers of the army and navy. At the last of these the writer, who had just returned from Europe, was present, and trials were then made upon the effect of shells of a peculiar construction, which were prepared by him. These shells are hermetically sealed, and are effectually secured from accidental explosion, either from fire or from violent concussion. They are perfectly safe, also, from injury by submersion in water. They are so constructed as to explode after having penetrated the object against which they are discharged; and being elongated, contain three times as much powder as the common shell of the same caliber. They do not require the use of mortars, but may be fired from the guns in ordinary use. Out of twenty of these shells which were discharged into timber, or into banks of sand, nineteen exploded in the manner anticipated, rendering their action sufficiently certain, and evincing the possession of properties not possessed by any other shell, and producing effects which were actually tremendous.

It will be manifest that a steam vessel or battery, fortified in the manner described, furnished with the means of rapid propulsion, would be able to approach an adversary's vessel so securely, and so closely, as to render it nearly impossible to miss her with shells fired horizontally; and it does appear that a vessel possessing the properties above enumerated would be able to attack and destroy any fleet of steamers, or of sailing ships, as now constructed, which might be sent to attack a city or blockade a port. The part of such a vessel through which the guns are fired, having a thickness of 4 inches or 5 inches only, might have portholes but little larger than the muzzle of a gun, and yet allow it to be fired at any desired angle. These portholes may be readily protected from canister, grape or other shot by means of movable screens so constructed as to be removed and replaced with facility.

A single shell of large dimensions, and of the kind prepared by the writer, will suffice to sink the stoutest wooden vessel if exploded within her sides anywhere near the water line. The effect of such a shell upon a structure of wood was fully tested, under his superintendence, upon Governor's Island in the harbor of New York upward of twenty years ago. The experiment was made by the late Col. James House and several other officers, with the following result: A target of white oak was constructed in the strongest manner by one of the best shipbuilders. It measured five feet in thickness, and the timbers were secured together by iron screw bolts passing entirely through the whole. This target was perforated by the explosion of a single shell, a hole being made in it through which a horse might have passed. Seven timbers of white oak, each measuring 12 inches by 16 inches, were torn into shreds, and scattered to a great distance.

The foregoing plan of constructing and arming a vessel, with most of its details, has been matured for many years, and the delay in bringing it forward has resulted from a conviction that a period more favorable to its adoption than any that has heretofore occurred would arrive, and it is believed that it has now actually arrived. As a means of defense it would be cheaper than any other. In actual service her crew of all grades would not probably exceed one hundred and fifty. She would need no rigging. With anthracite as fuel she would not be rendered visible either by smoke or by sparks, and would therefore attract the notice of an enemy the less, either by night or by day, than any other vessel. ROBERT L. STEVENS.

The following letter on the same general subject was written at a later period by John C. Stevens, a brother of Robert L. Stevens and Edwin A. Stevens, and one of the signers of the letter to the Joint Navy and Army board of August 13, 1841:

New York, January, 1846.

Mess. Gales and Seaton*: It is often asserted that in a sudden declaration of war against us by England we should be likely to get, for the first year at least, very much the worst of it, owing to her efficient preparation, and our want of it. What injury British cruisers could inflict upon our commerce I do not know, but they have merchant ships at sea as well as ourselves, and as it is a game two can play at, the advantages are not likely to be all on one side. With regard to the apprehended destruction of our cities on the seaboard, I believe this danger may be very much lessened, or perhaps entirely warded off, and at an expense comparatively trifling. The suggestion will at least cost nothing. The government in 1841 appointed a board of army and navy officers to assemble at Sandy Hook to witness some experiments to be made by my brother Edwin and myself to show the effect of shots and shells upon wrought iron, and to report the result.

Com. Stewart was at the head of the naval, and Col. Totten at the head of the army committee. A target two or three feet wide by four or five feet high, and four and a half inches thick, made of wrought-iron plates riveted together, was set up at 30 yards from the gun, that the initial velocity and of course greater effect of the shot might be obtained. Many of the different size shots, varying from 24 to 64 pounds weight, together with a number of the heavier shells, were fired into it. The shot were *in every instance* broken into minute fragments. No vestige of the 24-pound shot remained; of the 64-pound shot, a small core an inch or an inch and a half in diameter was left in the indentation made, the exterior surface of the ball being entirely dissipated. As to the shells, they were broken to pieces, leaving scarcely a mark to show where they had struck. A man would have been as safe from shot or shell behind this shield as if he had been thirty miles instead of thirty yards from the muzzle of the gun.

By referring to the report of the board of officers made at the time, you will find this proved. Should ocular demonstration of its truth be wanted, the government may satisfy itself by making the experiment. It can be done in half a day, and at an expense of fifty dollars. I would propose then to construct an *iron shield* for every gun not already protected by a battery, as an additional defence to such cities or harbors as may be deemed insecurely fortified. Those

* Gales and Seaton were publishers at Washington, D. C., of "Congressional Debates."

shields should be large enough, and no larger than necessary, to protect as many men as are required to work the gun. A shield 4 inches thick, 10 feet long, and 7 feet high, hinged together in such handy panels as to admit of being arranged in an angular or semicircular form, and as easily set up or removed as the gun itself, would, in my opinion, be a perfect protection from either shot or shell. If this be true, then, as I aver it to be, what would be the effect of 100 or 500 guns so shielded upon a fleet of wooden vessels? If the guns be manned by Yankees and charged with hot shot or shell, those who make the trial will find it much easier to get within than without the range of such missiles.

Satisfy a man that he is safer behind this shield than he can be anywhere else within striking distance of a shot, and you will be in no want of men to work as many guns as the government may choose to furnish. What sort of a fight would a 74 (gun frigate) make with *one gun* so protected? The one presents a surface of 200 feet long by 15 or 20 feet high, and vulnerable at every point; the other a surface of ten feet by seven feet, and invulnerable. A single shell might sink the one, while a thousand would be as harmless to the other as so many eggs thrown against a wall. The weight of the shield compared to that of the ball is so great as to preclude the possibility of its being thrown down or even moved by the shock of the heaviest shot carried by a vessel of war at present. If they get heavier guns, get thicker shields. How many guns so shielded it would require to protect a harbor or city, the officers of the army and navy are best able to say. I am satisfied that the greatest bungler that ever applied a match would not fail under such circumstances to hit a ship.

Those who have witnessed the effect of an American shell fairly embedded in a wooden hull, will be at no loss to predict the fate of a vessel pierced by such a missile. The cities might have their guns and shields as they have their fire engines, ready at the ringing of a bell to take the station previously assigned them. The wharves and shores of New York and New Jersey in an hour's time might bristle with cannon more difficult to dismount or silence than ever pointed at a foe. No forts and but little expense of either men or money would be required. Companies would be formed as fire companies are, ready and willing to serve as many guns as the government or city would furnish them. The weight of a target 10 feet long, 7 feet high, and 4 inches thick, which at the distance the guns would probably be fired would be thick enough, will weigh 7,500 pounds, a little more than a load for a good four-horse team. Its cost would be $750. To protect one hundred guns would cost $75,000. What a fort constructed of stone, and much less efficient, with all its paraphernalia, etc., would cost I do not know; perhaps ten or twenty times as much.

In the stone fort the wide embrasures render the guns liable to be dismounted. With the iron there is no such danger. The aperture need be but little larger than the muzzle of the gun, to give a much wider range than can be had from any embrasure. The iron defence has another advantage: its front may be changed or its position shifted to any spot rendered by circumstances more desirable. Less than one-half inch of iron will protect a soldier from a musket or rifle shot. A breastwork to cover a front of 500 feet might be carried in twenty ordinary wagons, and set down or taken up with as much facility as a gun and its carriage can be placed in or removed from its position. There is iron enough in the country to make in one or two months' time as many shields as would be required. It is true, the simple riveting together of iron plates of any thickness, the most common blacksmith can execute. Every town or exposed place might have a gun or fort of its own. Fortunately for us, we wish but to repel the attack of others.

These shields, together with such a steamship as the government has authorized R. L. Stevens to build, will put it in our power. A steamship or battery, such as he is about constructing, impenetrable to shots or shells, and capable of moving with greater rapidity than any other ship afloat, will in my judgment be more than a match for the largest fleet of wooden vessels that England or any other power can bring into the bay, or against the city of New York.

JOHN C. STEVENS.

The introduction of the bill in Congress for the construction of this armored vessel was made in February, 1842, and in two months had become a law. This appears to be a very short time for such a measure carrying an appropriation of money, to be before Congress, but there was as much, if not more, interest taken in the subject by the navy and war departments to see the experiment made, than there was for any private interest to be served. There was also some agitation of war with Great Britain at this time by the politicians and contractors over the question of the Oregon boundary. There was an effort made during the progress of the bill through the House of Representatives to have a provision inserted requiring that the iron from which the vessel was constructed should be wholly of American manufacture, but this failed to meet the approval of that legislative body. The larger machine tools for the working of the material used in the building of the vessel and machinery, and some of the heavier plate iron to be used in the structure, were imported from Great Britain.

In the summer of 1843 work was begun in excavating for the drydock in which to build the vessel, and considerable of the necessary cutting was through solid rock. This dock was about 300 feet long and 120 feet wide. There were also brick buildings erected for machine shops and a boiler shop, alongside the drydock, for preparing the material for construction before its erection in the basin. The vessel as now designed was to be an iron hull of 250 feet by 40 feet by 28 feet deep, and to be constructed of plate iron of an average thickness of one-half inch. The angle iron frames were to be 6 inches deep, and from ⅜ inch to ½ inch thick, and spaced two feet apart, except under the engines and boilers. There were to be four or more condensing engines, with four iron boilers, wrought-iron main shafts, and an artificial blast for the boiler furnaces operated by an independent engine. The motive power was to be below the water line of the vessel, and operating twin screws. The armor plating, at and above the water line as then proposed, was to be 4½ inches thick. It was intended to fit the vessel with a large Paixhan or shell gun, to be located in the bow of the vessel on the main deck, and to be protected from the enemy's shot and shell by a bombproof covering.

The plant for the building of this vessel was in readiness for the commencement of the work by the fall of 1844, but nothing seems to have been done under the contract. Otherwise we find that in the spring or summer of 1845 work was begun in the yard on the iron-hull steamboat "John Stevens," an account of which is given in the SCIENTIFIC AMERICAN SUPPLEMENT of October 28, 1905, in article on "Iron and Steel Hull Steam Vessels of the United States," and the vessel completed for service in May, 1846. The official report of the bureau of construction of the Navy Department for 1845 says regarding the war steamer: "At Hoboken, N. J., iron steamer has been contracted for"; for 1846 to 1851 inclusive, "At Hoboken, N. J., iron steamer, building suspended"; and for 1852, "Stevens iron steamer at Hoboken, N. J., in progress of construction." While the official reports do not indicate that there was any work of erection from the original design, still it has been stated that there was a short length of keel, and a few frames erected, after the "John Stevens" was finished. If so, this was as far as the construction work ever got in the early stages.

That the improvement made in the naval gun had much to do with the delay in building this vessel is without doubt. There had been very little if any change made in our naval artillery from the close of the war of 1812 to the period under review. With the addition of steam vessels to our navy began a period of progress in the armament of our naval vessels. In 1841 an improved "Columbiad" of a different model from the Paixhan gun was introduced into the service, and a battery composed of 10-inch and 8-inch guns of this type were placed on each of the steam frigates then completed; and a few years later this type of gun was further improved with increased weight and greater power. During the Mexican war there were three or more naval vessels fitted with shell guns. There were also the two 12-inch wrought-iron guns on the naval steamer "Princeton." The desire to know of the efficiency of these guns during the Mexican war may have been one of the causes of the later delay in commencing operations on the vessel. In 1844 Prof. Daniel Treadwell introduced in this country the principle of the "hooping" of naval guns. A 12-inch Columbiad gun was cast at South Boston, Mass., in 1846 that was "hooped." The wrought-iron gun was no longer taken into consideration for experiment, after the explosion on the "Princeton" of one of her 12-inch wrought-iron guns. This gun was forged at the works of L. B. Ward & Co. in New York city, the only works fitted with tools to do such heavy forging at the time. We thus see that the first steps had been taken in producing an improved type of gun for the naval service, prior to any work being commenced in the erection of the iron armored war steamer. The experiments with these later types of guns destroyed all confidence formerly felt in the 4½-inch armor proposed for the vessel. These experiments with cast-iron guns were continued for a long period and at frequent intervals; discouragements and failures followed for a few years, but they finally developed in about ten years in the Dahlgren gun and later the Rodman gun. The rifled cannon was not produced in Europe until about 1855.

After the failure of the "Princeton's" wrought-iron gun, there was considerable attention given to strengthening the naval gun. About the same time iron-hull steam vessels were receiving more attention in Congress, and in 1846 there was a report made by the naval committee of the House of Representatives recommending iron in the construction of all naval vessels on account of its strength combined with lightness, economy in repairs, and the advantage that it will to a considerable degree obviate the destructive effects of Paixhan or hollow shot." One of the provisions for these vessels was to be their capacity to carry an armament equal at least to six of Treadwell's wrought-iron guns of 12 inches caliber. Various proposals were made to construct these vessels, one of which was from John Ericsson to build a steamer of 1,200 tons, with his submerged propellers, for $390,000, with all her armament complete. This measure did not get any further than the committee. It had too much iron and steam, with further modern improvements about it.

There were other causes than the improvement of naval ordnance at this period that contributed to the delay in the prosecution of the work on this vessel. There were a number of officers of the higher rank in the service who were opposed to the introduction of steam vessels in the navy, and who said at the time, "We are being steamed to death." As for an iron-hull, armored, steam war vessel, that was the height of folly; it was too much of the engineer's vessel to suit them. Some of these officers still retained this opinon at the opening of our civil war. Any progress that brought steam and an engineer into the naval service gave this element the nightmare. There were several engineers from the merchant service who entered the naval service about 1844, but on account of the exactions of the service at the time they passed in their resignations in about a year, and left the navy for more pleasant employment. The engineers in the navy had their own trials on board the vessels at this period. Besides these naval officers, there were the rival interests at the time, that were engaged in bringing the screw propeller forward as a means of propulsion to steam vessels; and last, but not least, the advocates in private life of wooden-hull steam vessels for our navy. This combination of interests made their power felt at Washington soon after the contract was made for the armored vessel. Commodore Perry was sent to the scene of strife during the Mexican war, and Col. George Bomford died in 1848, so that the contractor lost the aid and counsel of these advisers in the earlier stages of the work.

That the factor of politics entered into the business, there is no doubt. The opposing interests put impediments in the way of carrying forward the enterprise, through official channels and otherwise, and it was not until 1852, when the dominant political party of the country at the time came once more into full control of both the executive as well as the legislative branches of the government at Washington, that the friction of opposing interests had almost entirely lost its effect, and the enterprise was again placed on good ground by a renewal of the contract, and a little later a further appropriation of money by Congress for the vessel. The contractor was in no sense a novice in the game of politics.

There were never, so far as known, any accusations made of "honest graft" in this contract, as the contractor was so much in love with his profession, that its ruling spirit raised him above the speculative government contractor. It was viewed in the light of an investment, as a waste of public money in promoting a visionary proposition. This was not the condition surrounding most of the large contracts made by the Navy Department during this period, for Senator Thomas H. Benton in his "Thirty Years' View" says of this time: "A powerful combined interest pushes forward an augmented navy, without regard to any object but their own interest in it. First the politicians who raise a clamor of war at the return of each presidential canvass, and a cry for ships to carry it on. Next the naval officers are always in favor of more ships, to give more commands. And third, the contractors who are to build these ships."

(To be continued.)

The best flour milled in this country undergoes an aging process before being placed on the market. The treatment causes it to absorb more water and bake a larger loaf and show improvement in many ways over the freshly-milled flour. The storage and other charges add materially to the cost of the flour, and experiments have been conducted for some time to bring about the same result in some more economical manner. An electrical apparatus has been recently perfected, by which this aging process is done in a few minutes. The result is accomplished by allowing the flour to come in contact with ionized air. The apparatus designed for the purpose comprises a generator, an air pump, and a make-and-break device operated by the same movement as the pump, all mounted on one base. At every stroke of the pump there is an electrical discharge brought about by the breaking of an arc in the interior of the pump, and the air thus ionized is conducted to any part of the mill through pipes, and is brought in contact with the finished product by being passed through the reels and agitators through which the flour passes as it comes from the mill.

TESTS OF ALCOHOL LAMPS AND STOVES.

WITH COMPARISONS OF MEASUREMENTS, OPERATIONS, POWER, AND FUEL CONSUMPTION.

BY S. M. WOODWARD AND B. P. FLEMING.

THAT alcohol has extensively replaced kerosene and other fuels for domestic lighting and heating in the continental countries of Europe is well understood, but knowledge of the forms and use of apparatus especially designed for alcohol, and of the merits and cost of alcohol as compared with other fuels, is still quite limited in the United States. Indeed, American inventors have given the subject of the design of suitable alcohol lighting and heating apparatus so little thought that, with the possible exception of small heaters such as have been used for chafing dishes and the like for years in this country, we must look almost entirely to the French and Germans for alcohol lamps and stoves.

The devising of apparatus which would give a brighter, safer, and more satisfactory light than the ordinary kerosene lamp in those households where gas and electricity are not available is a matter to which much attention has been given in Europe, but the difficulties to overcome have been such that development has been extremely slow. Kerosene incandescent burners were devised and put on the market more than ten years ago, but the lamps required too much care and technical knowledge for their successful operation to bring them into popular use. Attention was then turned to alcohol, which proved a more satisfactory fuel so far as requirements of the incandescent mantle are concerned, and we find, therefore, on the German and French markets to-day a large number of alcohol burners, most of which give an excellent light, with absolute safety from explosion, with no production of soot, and with but small consumption of alcohol.

FIG. 1.—COHN HANGING ALCOHOL LAMP. GERMAN MANUFACTURE.

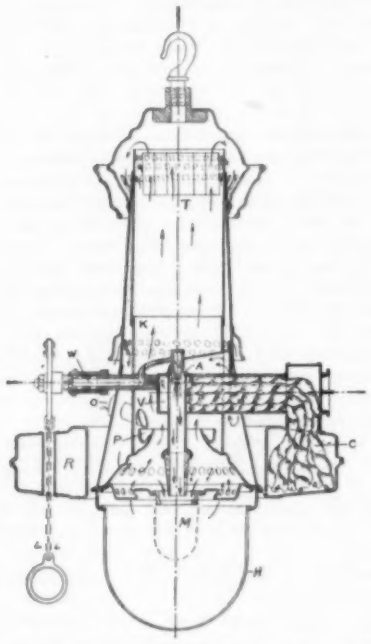


FIG. 2.—SECTION THROUGH COHN HANGING LAMP SHOWING INTERIOR CONSTRUCTION.

Little is known with regard to the operation and fuel consumption of such apparatus in this country, and at the present price of alcohol many questions of economy must be solved if these lamps and heaters are to come into general use. In view of this fact and having secured the use of a quantity of such apparatus, the writers recently made a number of tests on four alcohol incandescent lamps of foreign manufacture for fuel consumption and candle-power, tests also being made upon a representative kerosene lamp for purposes of comparison. In addition, the operation and fuel consumption of a number of small alcohol stoves were investigated, one of the stoves being made by a firm in this country. The tests were carried on in the physical laboratories of George Washington University at Washington, D. C., use being made of the excellent laboratory equipment of that institution.

The candle-power was measured by a Bunsen photometer, the standard being an incandescent electric light of 17.2 candle-power at 110 volts. To maintain the required voltage a rheostat was placed in the lamp circuit and adjusted as necessary until the potential was correct, as shown by a voltmeter. To determine the fuel consumption the lamp was filled with alcohol, lighted and placed upon a pair of balances reading to 0.1 gramme. The lamp remained upon the scales during the test and thus a continuous record was obtained by determining the loss of weight at frequent intervals of time, enabling the hourly fuel consumption of each lamp to be directly calculated. The stoves were tested by measuring the length of time required and the amount of fuel consumed in heating a weighed amount of water from room temperature to near the boiling point. Fuel consumption was measured by weighing, as with the lamps. With both lamps and stoves, determinations were made, when possible, of the operation at various needle-valve settings.

The fuel used was denatured alcohol known to the trade as "pyro." It was purchased at a local drug store and was marked "188 degrees proof, guaranteed by the United States Industrial Alcohol Company." The test of this alcohol by hydrometer showed a specific gravity of 0.817 at 18 deg. C., or 64.4 deg. F., which by reference to an alcohol specific gravity table shows that the alcohol was approximately 94 per cent pure or 188 deg. proof as guaranteed. Alcohol of this strength has a weight of 6.83 pounds per gallon at 60 deg. F., and this value was used in converting weight to volumes. A careful calorimeter test was made as to the calorific power of this alcohol, from which it was found that its heat of combustion was 6,695 calories (high value) or 12,051 B. T. U. per pound.

Four illuminating lamps were tested, each made by a different maker and of somewhat variant types. Fig. 1 shows a hanging lamp intended for store and outdoor use, rated at 70 horizontal candle-power and made by M. Cohn, Jr., Berlin. The lamp is quite simple in construction, consisting merely of a fuel reservoir, *R* (see Fig. 2), and containing a cotton wick, *C*, which feeds alcohol into the vaporizing chamber, *V*, contained within the chimney. The vapor issues from a nozzle, as shown in the cross section, and flows downward to the mantle shown at *M*, mixing with air, as in the usual Bunsen burner, the air entering around the nozzle at *A*. The flow is controlled by the valve, *W*, opened and shut by the use of hanging chains, *L L*. The mantle is surrounded by a hemispherical glass cover, *H*, and the heated products of combustion rise through an inner portion of the chimney, *K*, heating the air supplied, which passes down on the outside of the hot portion of the exhaust gas tube, thus being considerably raised in tempera-

FIG. 3.—COHN TABLE ALCOHOL LAMP. GERMAN MANUFACTURE.

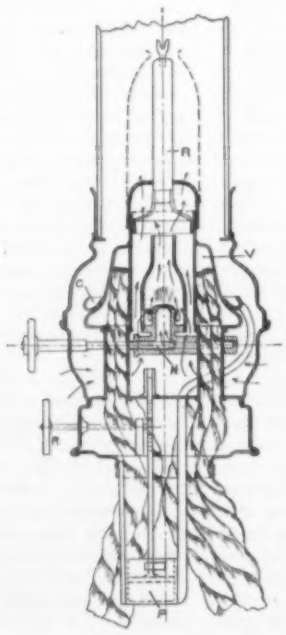


FIG. 4.—SECTION THROUGH COHN TABLE LAMP.

FIG. 5.—BEC NATIONAL. FRENCH ALCOHOL LAMP.

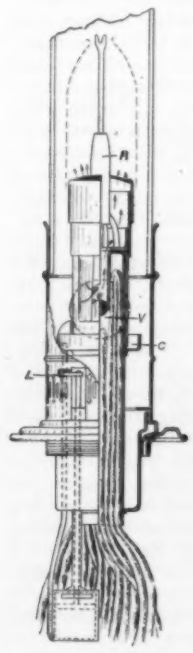


FIG. 6.—SECTION THROUGH BEC NATIONAL.

FIG. 7.—A SIMPLER BUT LESS SATISFACTORY FRENCH ALCOHOL LAMP.

ture before combining with the vapor. The gases escape through the top of the chimney at *T*.

The starting of the lamp is a relatively simple operation. After filling the fuel basin, *R*, a small quantity of alcohol is poured through the opening, *O*, into a little cup, *P*, below the vaporizing chamber. This alcohol is then ignited and the opening, *O*, closed. After about a minute the needle valve is opened by pulling one of the chains. Another minute elapses before the mantle becomes heated to incandescence. The candle-power was measured both horizontally and vertically. The former averaged 30.5, the latter 36.2. No means are provided with this lamp for changing the needle-valve setting while in operation and the values given represent the average of one hour's operation at full needle-valve opening. The fuel consumption was 0.0229 gallon per hour, or, estimating upon horizontal candle-power, 0.75 gallon per 1,000 candle-power hours; or, in other words, 1 gallon of alcohol would be sufficient for 44 hours' operation.

Fig. 3 shows a burner adapted for use as a table lamp. The burner is quite ornate and with a tall glass chimney makes a decidedly pleasing appearance. The lamp is made by the same firm as above and is rated at 70 candle-power.

Fig. 4 shows the arrangement of the parts, it being seen that the lamp (as were all of those tested) is of the wick type, the wick conducting the alcohol to a vaporizing chamber from which the vapor issues into a Bunsen burner arrangement and burns at the top in a blue flame, heating the mantle to incandescence. The initial heating necessary to produce the vapor at starting is secured by burning a small quantity of alcohol in the cup, *C*, but during operation the heat conducted to the vaporizing chamber, *V*, down through the rod, *R*, which supports the mantle, is sufficient to carry on the necessary vaporization. A needle-valve, *N*, controls the exit of the vapor from the vaporizing chamber. In starting, a small quantity of alcohol is pumped up from the fuel basin by the pump, *P*, into the cup, *C*, the pump being operated by alternately turning back and forth a thumb nut, *R*. The alcohol in the cup is ignited and after a few seconds the needle valve, *N*, is opened a short distance, allowing the vapor to escape. It almost immediately ignites from the flame of the cup and the mantle soon becomes incandescent. The entire time of starting consumes about 45 seconds, counting from the instant that the pump is started to the time when the mantle begins to glow.

The range of possible settings of the needle valve is small, the maximum illumination of 24 candle-power, as determined, being secured with an opening of only one-eighth turn. An opening of one-half turn of the valve in this case produced undesirable blue flame above the mantle. The fuel consumption at the maximum candle-power stated above was 0.0191 gallon per hour, or 0.8 gallon per 1,000 candle-power hours. A gallon of alcohol would therefore suffice for 52 hours' operation.

Fig. 5 shows a smaller lamp, somewhat different in arrangement of details from that last described. It is called the *bec national*, being made in France by E. Boivin & Co. In this lamp the pump is operated by a direct stroke by pushing down the spring-opposed lever, *L* (see Fig. 6, a partial section of the lamp). As shown by the diagram, a wick elevates the alcohol to a vaporizing chamber, *V*, from which it issues under control of a needle valve not clearly shown, and burns at the top of a burner similar to the usual Bunsen burner. The heating of the vaporizer is produced initially by the combustion of alcohol in the cup, *C*, and

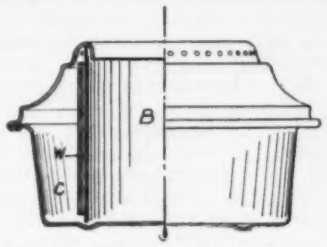


FIG. 9.—SECTION THROUGH TYPICAL SMALL ALCOHOL STOVE.

during operation by the heat conducted to the chamber by the rod, *R*. The operation at starting this lamp is substantially the same as in the previous cases, the time required being, however, somewhat longer, or about 80 seconds, although this varies with the experience of the operator. Since this lamp is provided with a needle valve the candle-power can be varied within

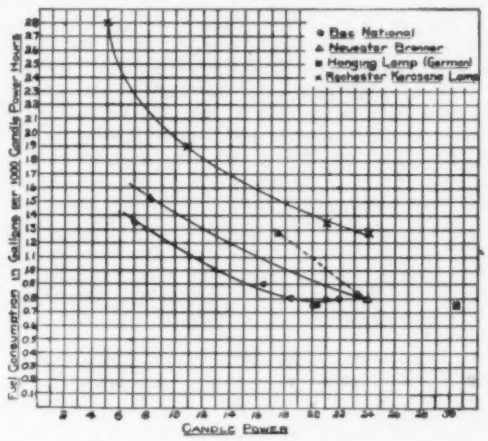


DIAGRAM I.—SHOWING THE RELATIVE FUEL CONSUMPTION OF VARIOUS ALCOHOL AND KEROSENE LAMPS.

narrow limits and in the tests here reported it was determined for eight different settings of the needle valve. These results have been plotted in Diagram 1. The maximum candle-power secured was with the needle valve open about three-fourths of a turn, its average at this setting being 22 candle-power. If the needle valve was closed below this value the light was reduced, and when the opening was about one-fourth turn the light became dim and finally flickered out, probably through insufficient heating of the vaporizing chamber. Greater openings of the needle valve than the most favorable increased the fuel consumption but not the candle-power by any appreciable amount. A slight hissing is noticeable, as with the ordinary Welsbach burner, and if sufficient excess of alcohol vapor is admitted the characteristic blue flame appears above the chimney. The lamp was tested for several hours and the fuel consumption at the maximum candle-power was 0.176 gallon per hour, or as in the other case, 0.80 gallon per 1,000 candle-power hours, or 1 gallon of alcohol will last 57 hours of continuous operation.

Fig. 7 shows a lamp which proved entirely unsuccessful in the test, it being impossible to secure more than a very feeble and unsatisfactory light. The cause seemed to lie in the unsuitable regulation of the air supply, causing the vapor to ignite and burn immediately upon issuing from the vaporizing chamber rather than at the top of the Bunsen burner. All attempts at adjustment of the air supply, for which more or less perfect means are provided, proved utterly fruitless, and the tests upon the lamp were therefore abandoned. One serious defect was found to exist in the fuel pumping and regulating devices, which in this burner are combined, both being functioned by one thumbscrew, shown in the figure.

The kerosene burner tested for the purpose of comparing candle-power and fuel consumption with the alcohol lamps was a circular No. 3 Rochester burner provided with a new wick and apparently in good condition. Four tests were made with the light varying from 5 to 24 candle-power, the fuel consumption being determined for each setting. The fuel consumed at the maximum of 24 candle-power was 0.31 [illegible] per hour, or 1.29 gallons per 1,000 candle-power hours. A gallon of kerosene would last 32 hours at this rate of consumption. The maximum candle-power probably could not have been maintained continuously without danger of smoke being produced. From 21 to 23 candle-power probably would have been about the maximum desirable in the ordinary usage. With this height of flame a gallon of kerosene would last 35 hours. The kerosene used was purchased in the open market, but no tests were made as to its specific gravity or heating value.

A summary of the relative illuminating values of alcohol and kerosene, as shown by the results of these tests, is shown graphically in the diagram. The candle-power developed is taken as a horizontal co-ordinate and the fuel consumption in gallons per 1,000 candle-power hours is read off on the vertical scale, the points representing the results obtained from different lamps are distinguished by the use of different symbols, as shown on the diagram. It is seen that the consumption is lowest at the maximum candle-power in every case, and that turning down the lamps, thereby reducing the candle-power, did not diminish the amount of fuel consumed in the same ratio as the light was decreased. For any lamp the different tests show that the relation between consumption and candle-power follows a fairly definite curve which is asymptotic to the axes in the case of the kerosene fuel. With alcohol fuel, however, there are indications that opening the needle valve beyond the most favorable

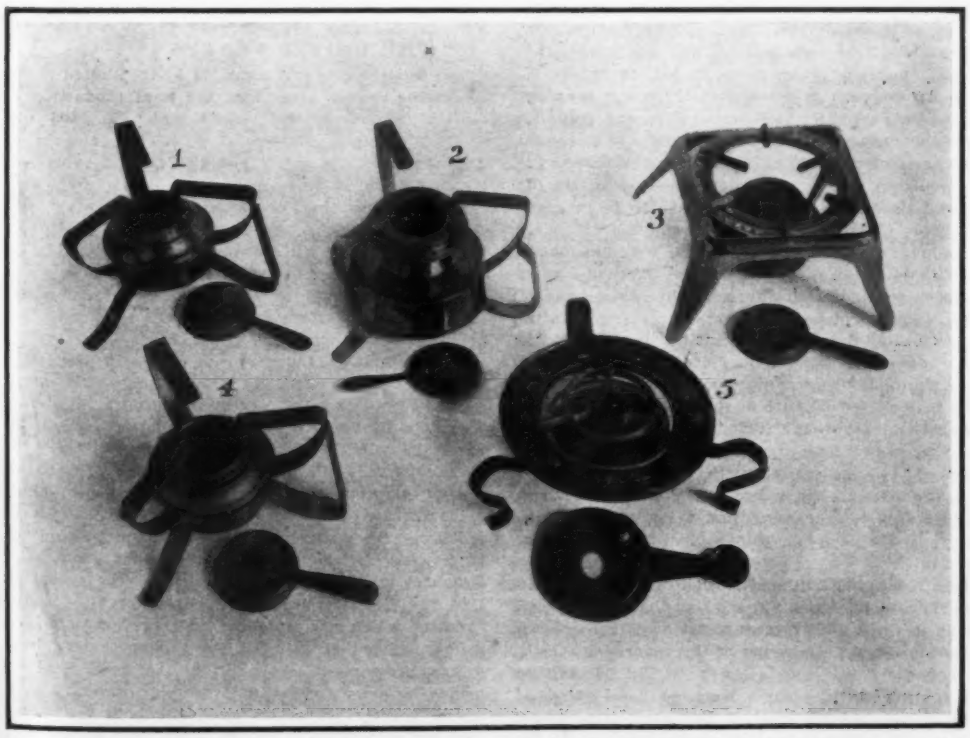


FIG. 8.—VARIOUS FORMS OF SMALL ALCOHOL STOVES OF FOREIGN MANUFACTURE.

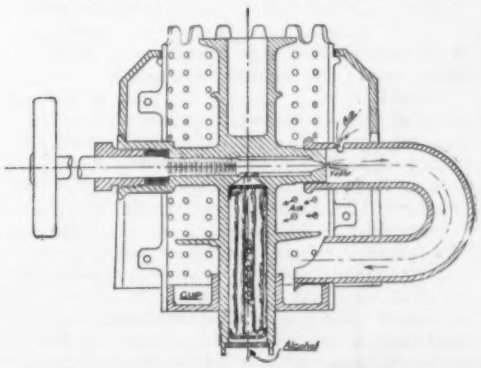


FIG. 10.—SECTION THROUGH BURNER OF "QUICK WORK" ALCOHOL STOVE.

FIG. 11.—SAD IRON HEATED BY INTERNAL ALCOHOL BURNER, AND AN EXTRA BURNER.

TESTS OF ALCOHOL LAMPS AND STOVES.

point, while increasing the fuel consumption, may finally decrease the amount of light obtained and the curve will make a loop and return upon itself, as is shown by dotted lines in the case of the Neuester Brenner lamp in the diagram, though this will depend upon the construction of the particular lamp with regard to the amount of heat conducted back to the vaporizing chamber.

It is seen that the curve for kerosene lies considerably above both of those for alcohol. Furthermore, the diagram shows that at best adjustment all the alcohol lamps used practically the same amount of fuel per 1,000 candle-power hours, namely, 0.8 gallon. On the other hand, the kerosene lamp required about 1.35 gallons per 1,000 candle-power hours at the most favorable point of operation, hence the kerosene consumption may be said to be about 1.7 times that of alcohol per candle-power hour on the basis of volumes. If kerosene sells at 15 cents per gallon, alcohol would have to sell at 25½ cents per gallon in order to furnish light at the same price. However, as compared with the kerosene lamp, the alcohol lamp has the advantage of being practically odorless in operation and of emitting an almost perfect white light, which is more pleasing in effect and agreeable in use than the yellow light of the kerosene burner. It has the disadvantage, however, of requiring much greater time in lighting, and the use of the mantle necessitates somewhat more careful handling, besides adding an extra element of expense. The mantles are, however, much less fragile than supposed; indeed, in the case of one of the lamps under consideration the lamp was carried by hand a considerable distance in the open air and the mantle was removed and replaced a number of times without apparent injury.

With regard to the mantles it may be said that so far as safety is concerned any mantle now used on ordinary gas burners may be equally well applied to use with alcohol. While it is perfectly possible that under certain conditions the alcohol lamp might explode as readily as the kerosene lamp, yet the peculiarities of alcohol are such that the flame resulting could be much more easily extinguished than that of kerosene under similar conditions.

The cost of lighting by incandescent electric lights at the usual rates charged in cities is about 60 cents per 1,000 candle-power hours, based upon a rate of 15 cents per kilowatt hour and upon a current consumption of 4 watts per candle-power. The ordinary Welsbach burner used for household purposes requires about 0.1 cubic foot of gas per candle-power hour, and the usual tip burner about 0.3 cubic foot per candle-power hour, which, with gas at $1 per 1,000 cubic feet would represent an expense of 10 to 30 cents per 1,000 candle-power hours, respectively. Using the results given above, the number of candle-power hours which can be purchased for $1 with different illuminants are as follows:

	Candle-power hours.
With kerosene at 15 cents per gallon...	4,900
With alcohol at 60 cents per gallon (retail)	2,080
With alcohol at 40 cents per gallon (wholesale)	3,120
With electricity at 15 cents per kilowatt hour	1,670
With gas at $1 per 1,000 cubic feet (tip burner)	3,330
With gas at $1 per 1,000 cubic feet (Welsbach burner).....	10,000

The foreign heating apparatus comprised a number of small stoves of the general type indicated in Fig. 8. While small, these stoves were found to produce a flame quite disproportionate to their size, it apparently being ample for the broiling of a steak or for the heating of a fair-sized kettle. The general arrangement of the parts of these lamps is shown by the diagram, Fig. 9, from which it is seen that there is a central basin, *B*, into which the alcohol is poured, which then enters the annular chamber, *C*, where it is absorbed by a wick, *W*. The wick being heated through the walls of the inner chamber the alcohol is vaporized and burns as it issues from numerous small holes seen at the top of the burner. The operation is decidedly simple, consisting merely in touching a match to the alcohol within the interior basin, which burns slowly for a few moments and then ignites the vapor as soon as it issues from the openings mentioned. With some of the lamps a small cover is provided to be placed over the interior basin, but this is omitted in the smaller sizes.

Heaters Nos. 1, 3, and 4, shown in Fig. 8, consumed 0.08 quart of alcohol while heating 1 quart of water from 20 to 98 deg. C. (68 to 208 deg. F.) in 40 minutes, the cost per quart of water heated being 1.2 cents and the cost of operation of the stove 1.8 cents per hour. Heater No. 2, which is somewhat larger than those last mentioned, consumed 0.043 quart in nine minutes while heating the same amount of water through the same range of temperature, the cost per quart of water heated being 0.64 cent, or in continuous operation the expense would be at the rate of 4.26 cents per hour. Similar results for heater No. 5 are 1.68 cents per quart and 3.9 cents per hour, while for a small American-made heater of the type usually employed on chafing dishes similar figures are 0.52 cent and 1.25 cents respectively. These heaters are all, of course, of small capacity and adapted mainly to such household operations as may be carried on with a chafing dish. Only one stove of larger capacity was tested, this being manufactured in this country by a firm in Cleveland, Ohio, and known as the "Quick Work" stove. It differs from the small heaters in having a burner of the type in which vaporization is secured previous to combustion in a way similar to incandescent lamps. No wick is used, the fuel being forced into the vaporizing chamber under hydrostatic head of the fuel supply kept in the reservoir elevated about 2 feet above the burner. A cross-section of this is shown in Fig. 10. The operation of the stove is not unlike that of the usual alcohol incandescent burner. Preliminary heating is secured by opening the needle valve and allowing a small amount of alcohol to flow into the cup, after which the valve is closed and the contents of the cup ignited. After this has been consumed the needle-valve is again opened and the vapor which issues is readily ignited, after which vaporization continues automatically. This stove was first tested with the ordinary 94 per cent alcohol, one burner being used to heat water. Various needle-valve settings were used, ranging from one-half turn to one and one-half turns open. The position of this valve was, however, found to make little or no material difference in the operation of the stove, the consumption being practically the same at all settings, though the time required to heat a given volume of water varied. Thus, at needle-valve opening of one-half the time required to heat 1 quart of water 21 to 98 deg. C. (70 to 208 deg. F.) was 1,000 seconds and the fuel consumption 0.046 quart. With the needle valve at three-fourths opening, corresponding values were 810 seconds and 0.045 quart. At one turn open, 820 seconds and 0.048 quart, and at one and one-half turns open, 820 seconds and 0.049 quart. The reduced fuel consumption at the smaller opening is due undoubtedly to the fact that less heat is dissipated with the smaller size flame. The needle valve at three-fourths open would probably be found the most satisfactory setting in actual use. With this setting the cost of heating a quart of water is 0.67 cent, with alcohol at 60 cents per gallon, and cost of operation would be 2.97 cents per hour per burner.

At the request of the manufacturers of the stove, some tests were made upon the use of alcohol of various dilutions. Sufficient water was added to a quantity of alcohol to make its specific gravity 0.85 at 24 deg. C. (75 deg. F.), which gave it a strength of approximately 80 per cent. Tests were made with this mixture similar to the 94 per cent alcohol, from which it was found that the most favorable needle-valve opening was, as in the previous case, at three-fourths turn, at which the fuel consumption was 0.06 quart, this heating 1 quart of water from 22 deg. to 98 deg. C. (72 to 208 deg. F.) in 840 seconds. Greater openings of valve increased the fuel consumption and made no appreciable reduction in the time, while a less opening greatly increased the time and slightly increased the fuel required. If enough water is added to the 94 per cent alcohol at 60 cents to make it 80 per cent by volume, the cost of the latter would be 51 cents per gallon. As compared, therefore, with the operation with 94 per cent alcohol we find that the cost of heating 1 quart of water through the same range of temperature would be 0.765 cent, and at most favorable setting of the valve the cost of operation would be 3.27 cents per hour, a loss of 0.3 cent per hour, which shows a distinct disadvantage in dilution, as might be expected because of the heat which must be expended in vaporizing the water content of the alcohol.

Alcohol at 75 per cent strength, while it would operate in the burner more or less perfectly, showed about 10 per cent greater consumption for the same effect, and, of course, a proportionate increase in cost of operation.

These results with diluted alcohol, while negative in character, are interesting in showing that such alcohol may be operated with success so far as actual combustion is concerned, in a burner of the vaporizing type.

A household sad iron is shown in Fig. 11, and an extra burner for the same mounted upon stand or holder is seen by the side of the iron. This forms an extremely convenient and satisfactory article for household use and would probably be highly esteemed during the summer season. The operation consists in filling the small spherical fuel reservoir, after which a small amount of alcohol is also poured into the shallow receptacle of the stand, the burner being placed upon the stand as shown. A few moments after lighting the alcohol in the holder or stand, vapor issues from the numerous small holes in the horizontal pipe and is immediately ignited. The burner may now be placed within the iron, which is soon heated to the temperature necessary for ironing. The time required from the moment of lighting to reach this temperature (about 300 deg.) is 8 minutes, and the alcohol is consumed at the rate of 0.129 quart per hour, making the expense of operation about 2 cents per hour, with alcohol at 60 cents.

EFFECT OF MOISTURE ON WOOD.

THE effect of water in softening organic tissue, as in wetting a piece of paper or a sponge, is well known, and so is the stiffening effect of drying. The same law applies to wood. By different methods of seasoning two pieces of the same stick may be given very different degrees of strength.

Wood in its green state contains moisture in the pores of the cells, like honey in a comb, and also in the substance of the cell walls. As seasoning begins, the moisture in the pores is first evaporated. This lessens the weight of the wood, but does not affect its strength. It is not until the moisture in the substance of the cell walls is drawn upon that the strength of the wood begins to increase. Scientifically, this point is known as the "fiber-saturation point." From this condition to that of absolute dryness the gain in the strength of wood is somewhat remarkable. In the case of spruce the strength is multiplied four times, indeed, spruce, in small sizes, thoroughly dried in an oven, is as strong, weight for weight, as steel. Even after the reabsorption of moisture, when the wood is again exposed to the air the strength of the sticks is still from 50 to 150 per cent greater than when it was green. When, in drying, the fiber-saturation point is passed, the strength of wood increases as drying progresses, in accordance with a definite law, and this law can be used to calculate from the strength of a stick at one degree of moisture what its strength will be at any other degree.

Manufacturers, engineers, and builders need to know not only the strength but the weakness of the materials they use, and for this reason they are quite as much interested in knowing how timoers are affected by moisture as they are in knowing how they are weakened by knots, checks, cross-grain, and other defects. It is obvious that where timbers are certain to be weakened by excessive moisture they will have to be used in larger sizes, for safety. So far, engineers of timber tests, while showing that small pieces gained greatly in strength, do not advise counting on the same results in the seasoning of large timbers, owing to the fact that the large timbers usually found in the market have defects which are sure to counterbalance the gain from seasoning.

The Forest Service has just issued a publication entitled "The Strength of Wood as Influenced by Moisture," in which are shown the strength of representative woods in all the degrees of moisture from the green state to absolute dryness, and the effects of resoaking.

PRODUCTION OF MINERAL WATERS IN THE UNITED STATES IN 1906.

THE final returns just compiled by the United States Geological Survey show that the total production of mineral waters in the United States in 1906 was 48,518,395 gallons, valued at $8,065,841, a gain of 1,974,034 gallons in output and $1,574,590 in value over the figures for 1905.

In compiling this year's returns the Survey has endeavored to make its statistics represent only natural waters, sold still or carbonated, in bulk or in bottles, excluding water used for city supplies, water given away or used by guests at resorts, and water marketed in the form of ginger ale and other soft drinks.

Minnesota leads the roster of States in production but not in total value, the sales representing chiefly table waters marketed locally. Wisconsin is a close second to Minnesota in production and far exceeds all States in value of output, the famous wells of Waukesha giving it this prominent position. The production of this State in 1906 was 8,252,718 gallons, valued at $2,422,694. New York ranks third in the list of producers, the water sold at Saratoga Springs and the large trade worked up by prominent table water springs giving the State its position. The output in 1906 was 6,481,074 gallons, valued at $893,476. Massachusetts, which was fourth in rank, produced 3,857,955 gallons, valued at $210,152, the product having been derived from many small springs that meet local demands for pure and pleasant drinking water.

Allowing for deductions made to confine the figures showing production to natural water sold as water, it appears that more mineral water was consumed in the United States last year than in any preceding year.

To ascertain whether the minute hand of a watch touches the glass, wipe the hand and put a little oil on it. Then the glass is closed and the hands turned. If the hand touches the glass in the slightest degree, visible circles will be formed.

IRON SLAG.

THE UTILIZATION OF A WASTE PRODUCT.

BY DR. THEODOR KOLLER.

Slag Wool.—Some years ago there was placed on the market by several iron-smelting furnaces a fibrous substance, deceptively similar in appearance to natural cotton. The difference between the new product and cotton consisted in the fact that the fibers were straight in place of curled, that the fibers had a glaze, and that the mass was not as soft to the touch as cotton.

The new product was produced by blowing a current of steam through a stream of fluid slag.

The mineral wool, as it is called, is so far produced only from blast-furnace slag; and according to Schliephake, to the best advantage by a blast of steam, while the slag is preferably discharged from the furnace by a Lürrmann slag form. A material disadvantage is the serious discomfort caused to the employees by the presence in the air of finely distributed fibers.

The employment of mineral wood is governed by its natural properties, and prominent among these is its extraordinary deficiency as a conductor of heat.

For jacketing pipe conductors, the mineral wool, in pieces of about 400 square inches, is laid up about the pipe as high as this can be effected by simple pressure of the hand, without striking. A layer of 3.14 inches suffices for the largest pipe, and pressed together in this proportion the wool is wound so closely with string or wire, that it remains attached to the inclosed object. After about 5 feet of a pipe conductor has been thus enveloped, coarse canvas is sewed over it, and this, to prevent the penetration of moisture, is coated with tar, for wet mineral wool is a better conductor of heat than the dry substance, as is the case with other poor conductors of heat. For 0.8361 square yard (1 square meter) of surface thus enveloped, about 8.81 pounds (4 kilogrammes) of mineral wool will be needed. In a steam pipe or cylinder thus covered, heat is hardly perceptible outside the covering.

From other practical authorities, objection is raised to this method of covering, that the canvas jacket is of little use, as under the influence of light and air it speedily rots, even if tarred.

It is therefore recommended, in covering pipes with mineral wool, to employ a sheet metal cylinder, having an interior diameter about 6 inches greater than the diameter of the pipe to be insulated. The sheet metal cylinder should be from 12 to 16 inches long and divided longitudinally into two halves, connected together by shackles, each half having a convenient handle at about the middle. These sheet-metal cylinders are disposed about the pipe, one end being closed by a flange or sleeve and the slag wool rammed into the space between the pipe and cylinder, which amounts, for the entire length, to about 3 inches. When the interspace is thus filled with wool, too vigorous tamping being avoided, the sheet-metal cylinder, by means of gentle movement to and fro, is loosened sufficiently to be drawn ahead, with the aid of the handles, the part of the wool exposed being wound with wire. Care must be taken that the forward progress of the sheet-metal cylinder keeps pace with the wire winding. The entire surface of the wool is painted with tar, and in addition a 0.2-inch coating of cement is given. From 220 to 265 pounds of mineral wool are used to produce a covering 3 inches thick for each 10.764 square feet (1 square meter) of surface.

Owing to its fireproof character, in combination with its exceptionally poor capacity as a conductor of heat, mineral wool is to be especially recommended as a filling for fireproof safes. Regarding its employment in elevated structures as a filling under floors, wainscoting, etc., Wolpert, in Kaiserslautern, gives expression to suspicions. "Mineral wool," he says, "contains at present invariably sulphide of calcium, which, under the influence of the carbonic acid contained in the air and the water used in washing down the wainscoting, is transformed into carbonate of lime and sulphureted hydrogen. The latter, as is well known, if breathed in any quantity, is a poisonous gas, and for this reason the mineral wool, before being adopted for the purpose described, should be tested for calcium sulphide. Some vinegar poured on to mineral wool, previously wetted with water, will develop the well-known odor of sulphureted hydrogen—reminiscent of rotten eggs—thus showing if the wool really contains calcium sulphide."

But this objection to the employment of mineral wool as a filling material for double floors, etc., goes, even according to Wolpert himself, too far; in his opinion, with the normal volumes of water and carbonic acid present in the atmosphere, a perceptible development of sulphureted hydrogen could hardly take place. In addition to its low standing as a conductor of heat, a covering of mineral wool possesses great durability, withstands a considerable degree of heat and is not subject to destruction by moisture, injurious gases, or vermin.

Manufacture of Slag Stones or Slag Bricks.—The manufacture of slag bricks dates back to the sixties. In Osnabrück at that time the fluid slag, like the lead in a shot tower, was allowed to fall about 8 feet into water, forming into large, bean-shaped lumps, which were used for ballast on railroads. The same was done long since in England, where the slag was broken in a Blake stone crusher and used as road material. The slag from the Bessemer process, when the raw iron was obtained from the spathic iron ore, owing to the lime it contained, was specially adapted for ashlar purposes.

In more modern times, the best process of utilizing the slag from blast furnaces is the granulation of the slag.

This product, the so-called slag gravel, can not only be employed with the best results as bedding material for railroad ties, but it likewise furnishes, mixed in the proper proportions with lime, excellent slag building stones and slag mortar.

The production of slag gravel is very simply effected, the fluid slag being allowed to run into water, in which the sudden cooling, in the case of thoroughly smelted slag, leads to a hardening into pumice-like slag, or slag not so perfectly melted, being coarsely granulated.

Slag stone is in no way inferior to good burned brick in usefulness, but it excels tile stone in regard to beauty of color and porosity. At first rather brittle, it hardens rapidly on exposure to the air; this hardening process continues for a long time, also after employment in building; and as the mortar is also mixed with slag gravel, a perfect union of the stones occurs, so that after some years a wall built of this material consists no longer of separate stones, but of a homogeneous mass.

At the Buderus Iron Works, Lollar, near Giessen, Prussia, bricks are made from blast-furnace slag by the following process: A portion of the glowing liquid slag, flowing from the blast furnaces, is allowed to run into iron receivers, mounted on cars. They are run to the working place for bricks, and after cooling, emptied. The blocks of slag gradually crumble, under exposure to the air, into a bluish-gray powder—slag powder. The greater portion of the red-hot molten slag runs into a channel with cold, rapidly-flowing water, is thereby granulated, and the slag sand produced is raised by an elevator and dumped into buckets on an overhead cableway that carry it to the work place, where the buckets are automatically emptied. Foundry-iron slag has proved best adapted for this purpose, because with this the stones are as light as possible. In manufacturing the pressed stones, the slag sand is mixed with the slag powder and lime milk in the following manner: Two-thirds of sand and one-third of slag powder are moistened with some lime milk. This moist mass is shoveled into presses and formed into stones. The automatic steam knuckle-joint lever presses made by Bernhardis' Son, G. E. Dracuert, Eilenburg, have proved very satisfactory.

The stones are made in two sizes, the small size 9.83 x 4.72 x 2.73 inches, the large size 9.83 x 4.72 x 3.93. They are bluish-gray in color and fairly porous. Both resting surfaces are made with recesses, to reduce the weight and allow of the use of a large quantity of mortar, with apparently narrow joints. The weight of a stone (large size), air dry, is approximately 7.275 pounds. The destruction of the stones is effected under a load of 154.32 pounds per square inch (70 kilogrammes per square meter). The capacity of the stones for absorbing water is great, and their fire-resisting properties not very considerable—red heat. The stones are not burned, only dried in the air.

Slag sand itself is a desirable addition to mortar. An excellent finishing mortar is composed of 2 parts of slag powder, 2 parts loam and 3 parts of slag sand, which does for rough plastering. For fine finishing a mixture of 1 part slag powder, 2 parts of white lime, and 4 parts of pit or river sand or also slag sand, which must, however, in this case be finely screened.

F. Kirrmeier, in Speyer-on-the-Rhine, makes molded stones from blast-furnace slag. The slag is cast in long slabs, which at suitable places are notched, so that when the different blocks are separated from the slabs, stones with a granular crystalline cleavage are obtained. The molds employed in carrying out the process consist of single walls, with open side walls to facilitate the admission of the slag. On the under side of the lid, on the floor, and at the sides of the molds, are three-cornered strips, which facilitate the preparation of the cast slabs into separate blocks, after cooling.

The slag brick owes it present excellence especially to the improvement in the brick press, also to the use of dry disintegrated lime, which is added to the slag gravel, containing up to 40 per cent of water, as required; for although the granulated slag, on account of the soluble silicic acid it contains, if pressed or stamped would harden of itself, this is effected more rapidly by the addition of lime. The hardening of the stones is due to the formation of carbonate of lime, as occurs in ordinary mortar, and especially by the formation of solid combinations between the soluble silica, the slag, and the lime mixed with them.

The manufacture of slag bricks is carried on as follows: The glowing, liquid slag is conducted through a suitable cast-iron gutter, through which a sufficient stream of cold water flows. This chills the slag, and causes it to resolve itself in part into sharp sand, in part into very brittle lumps, which can be crushed by slight pressure. The slag sand is transferred to collecting bins, from which, by means of scoop baskets, the sides of which are perforated, it is lifted and transferred to the forming shop. The mixture with lime milk is effected by introducing the slag sand, with the aid of shovels, into the mixing contrivance, the lime milk, of a consistency of 8 deg. to 10 deg., being admitted in the necessary quantity. The mixture of lime and slag sand is now shaped, preferably in a Stein brick-making apparatus. It is loaded in a basket, from which it is removed, with the aid of two stamps, to the brick-pressing machine, from which the finished bricks issue, to be removed by laborers to transport wagons. The formed bricks dry for eight days. Dark slag is not so well adapted to the production of bricks as the light-colored article.

Blast-Furnace Slag for Pavement.—Blast-furnace slag has proved admirably adapted for paving material.

The Altona iron-slag paving stones consist of crushed slag mixed with loam or clay as a binding material, pressed and burned until glazed.

The paving stones are laid on a bed of sand, only 3.149 inches (8 centimeters) deep, leveled and stamped down with an ordinary wooden rammer, and the joints run full of sand and water, so that the work of construction may be described as easy and also rapid.

These slag stones do not wear hollow, like sandstone flags, nor smooth, like granite blocks; they are easily taken up and as easily replaced, which is important in making excavations for gas, water, and similar service.

The prices of slag stones vary, according to circumstances and competition, from 225 to 280 marks ($54 to $67.20) per 1,000. To this price must be added the cost of loading, unloading, and transportation to the locality for use, which may be calculated at another 15 marks ($3.60) per thousand.

Blast-Furnace Slag for Glass.—According to a patent granted to Basley Britton, at the ironworks of the firm of Chesland & Fisher, Wellingborough, England, fluid blast-furnace slag is run directly from the furnace and made into glass. It is conducted into a receptacle pit holding three-quarters of a ton, where it is mixed with other suitable materials. The glass is said to be perfectly transparent, remarkably soft or plastic, it withstands acids, can be cut easily with a diamond, and is well adapted for the production of rough plates for roof coverings, skylights, etc. Owing to the fact that the heat in the slag can be employed in the manufacturing process, it can be cheaply produced.

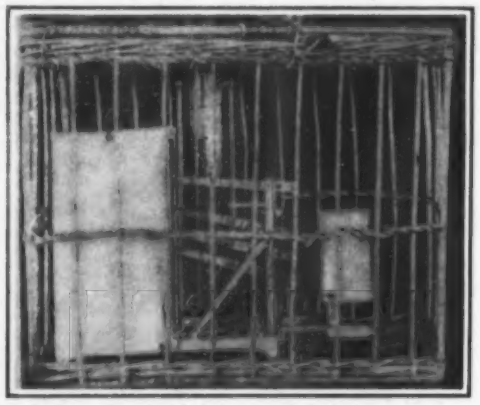
Working Blast-Furnace Slag for Salts.—The residual blast-furnace slag, according to a French patent, can be worked for the recovery of sulphate of alumina, gelatinous silicic acid, and calcium chloride, by placing the finely pulverized slag in an acid-proof apparatus and treating it with hydrochloric acid; the acid fumes generated are collected in sandstone receivers, filled with water, the acid solution drawn off (solution of silicic acid, chloride of alumina, and chloride of calcium) diluted with water, the silicic acid allowed to deposit, decanted, the alumina carefully precipitated with pure carbonate of lime, the precipitate washed out, dried, transformed by fuming sulphuric acid into sulphate of alumina, the jelly-like silicic acid cleansed by washing, and the calcium chloride solution, left by the precipitation of the alumina, concentrated by evaporation.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Verwerthung von Abfallstoffen aller Art.

NEW PROBLEMS OF THE WEATHER.

TEMPERATURE CONDITIONS AT GREAT ELEVATIONS SECURED BY KITES AND BALLOONS.

BY WILLIS L. MOORE, W. J. HUMPHREYS, AND O. L. FASSIG OF THE WEATHER BUREAU.

A KNOWLEDGE of the coming weather enters so intimately into every contemplated human action that the question is often asked: What are the prospects for further improvement in the accuracy of weather forecasts, and can the seasons ever be foretold? The



HERGESELL BALLOON METEOROGRAPH IN PROTECTING BASKET.

answer is that, while the government has a corps of forecasters who are now applying all of the knowledge of the atmosphere that has been revealed, little hope for material improvement in their work can be held out until a substantial addition is made to the pure science of the problem. This can only come through experiment, study, and research. With two hundred stations engaged in applying the science, it is a wise economy to devote at least one of them to the work of adding to the knowledge that is now costing us nearly a million and a half dollars annually to apply. Accordingly, those in charge have endeavored to lay out a plan of study and research leading to an increase in our knowledge of the laws governing the atmosphere such as should eventually enable our successors, if not ourselves, to add to the accuracy of weather forecasts and to make them for a longer period in advance.

In order that this country may do its share toward the advancement of meteorology along the lines that specially relate to conditions in America, it is imperative that the Weather Bureau should establish an observatory for its own special research work. A piece of land has therefore been secured and work has been inaugurated at an establishment that is intended to respond to the present and prospective needs of meteorology. This establishment is called the Mount Weather Research Observatory, and is organized on a broad and elastic basis, so that it may from year to year expand with the growing knowledge of our needs.

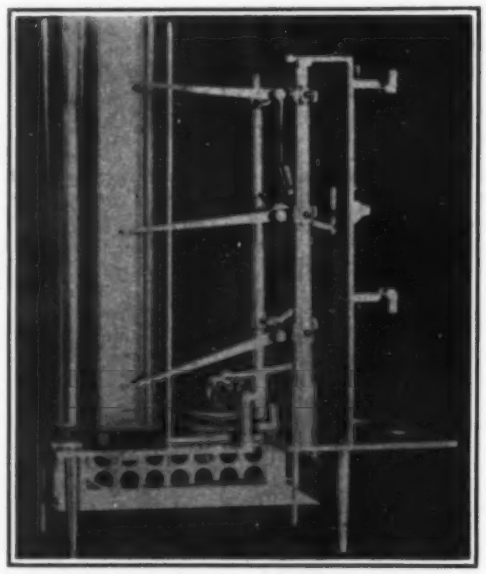
In order to prosecute the researches contemplated at Mount Weather, a plant has been established there especially adapted to the investigation of the physical condition of the atmosphere at great elevations above the surface of the earth. Hitherto our knowledge of the conditions of temperature, pressure, humidity, and wind velocity and direction has been based upon observations made at or near the surface of the earth or

THE SIEGSFELD KITE BALLOON.

upon mountain peaks. Current conceptions of the laws of storms and of the general circulation of the atmosphere are based upon such observations almost entirely. Records obtained in recent years by means of balloons have demonstrated the existence of hitherto unsuspected variations and contrasts in temperature at very great elevations, and have shown that observations on mountain tops and at equal elevations in the free air vary widely.

The necessity for a better knowledge of temperature conditions at great elevations has directed the minds of many meteorologists to the study of the best methods for lifting self-recording instruments high above the earth's surface. The result has been the invention in recent years of ingenious forms of kites and of specially designed balloons for this purpose. The kite has again become an instrument for scientific research, and now enables us to bring down records of atmospheric conditions at elevations of two and three miles, and even of four miles, as was recently demonstrated at the German aeronautical observatory near Lindenberg. By means of small rubber balloons, marvelously light self-recording instruments have been carried up to the remarkable heights of 10 to 15 miles, bringing back records of low temperatures and high wind velocities which have been a revelation to meteorologists—records which are compelling a reconstruction of existing ideas concerning the dynamics of the atmosphere.

Pioneer work along these lines was begun some years ago by means of kites, both at Weather Bureau stations, and, under the direction of Mr. A. L. Rotch, at the Blue Hill Observatory, near Boston, Mass. By experiments begun at St. Louis at the time of the World's Fair in the summer of 1904, Mr. Rotch also



FRENCH BALLOON METEOROGRAPH.

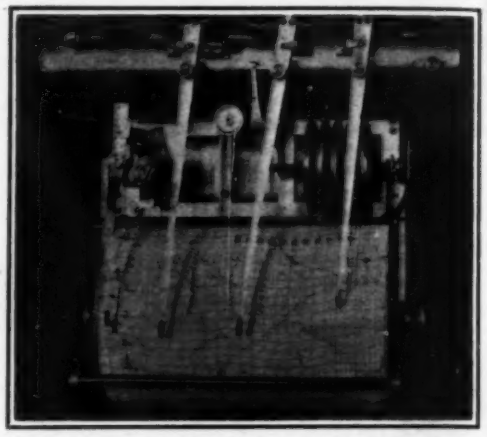
initiated the practice in this country of sending up small rubber balloons.

The observatory at Mount Weather is now well equipped with the necessary plant for carrying on this new and promising work of aerial research, and has for nearly a year been co-operating with European institutions and with the Blue Hill Observatory in sending up, on prearranged days, kites or captive balloons. These kites may be raised in winds varying from 10 miles to 35 or 40 miles per hour at the surface. With winds of less than 10 miles per hour it is necessary to employ captive balloons. To attain great heights small free rubber balloons of 2 or 3 cubic yards capacity, called pilot balloons, are employed. The instruments carried by the kites and balloons vary in weight from 1½ to 3 or 4 pounds and record variations in the temperature, the pressure, the humidity of the air, and the wind velocity.

The balloons are filled with hydrogen gas in order to secure the greatest lifting power. This necessitates the use of special apparatus for the manufacture of hydrogen. At the Mount Weather Research Observatory a strong electric current is passed through water, breaking up the liquid into its constituent elements of hydrogen and oxygen. These gases are then collected and stored in appropriate tanks for future use as occasion may require.

As the small pilot balloons carry up their instruments to heights of many miles, where the prevailing temperatures are at all times very low (sometimes exceeding 100 deg. Fahrenheit below zero), it is necessary to test the accuracy of the thermographs at these low points. For this purpose the observatory is equipped with a plant for the manufacture of liquid air, by means of which the instruments may be tested to the lowest points likely to be reached at great elevations.

In the near future these small rubber pilot balloons,

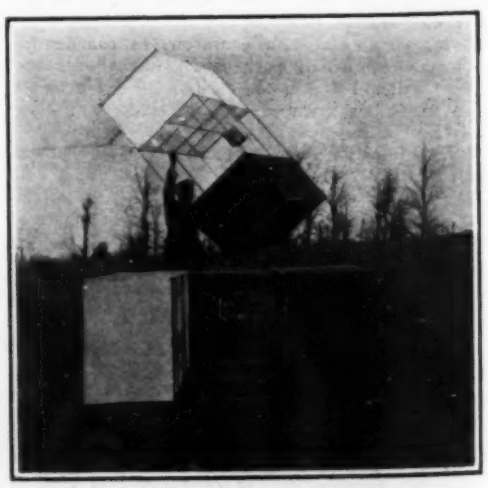


MARVIN METEOROGRAPH, WITH RECORD.

carrying with them to elevations of 30,000 to 50,000 feet the light self-recording instruments referred to, will be liberated simultaneously at twenty to thirty Weather Bureau stations surrounding typical storm centers. Observations obtained in this manner at various elevations when compared with the records made at the same time at the surface of the earth will doubtless throw much new light upon the mechanism of storms, cold waves, etc., and give to meteorologists a better understanding of the general circulation of the atmosphere.

As one of the primary objects in view in establishing Mount Weather Observatory is to make a study of the relations existing between the various forms of solar radiation and terrestrial weather conditions, much attention has been given to the instrumental equipment and to securing men to study the variations in the amount of heat energy given off by the sun from day to day and variations in the amount of heat absorbed by the atmosphere. Some work along these lines has already been done; but a special building and instruments will soon be necessary for the study of these important problems of solar physics.

At present the most sensitive index of changes in solar energy is the suspended magnet. There is no doubt that changes in the intensity and direction of the magnetic force as registered at the earth's surface are coincident with the appearance and disappearance of certain well-recognized periodic phenomena observed on the face of the sun. It is fortunate that we have in the magnetism of the earth a terrestrial element which varies in delicate sympathetic relation with the activities of the sun and is at the same time subject to continuous observation and registration. To appreciate the value of terrestrial magnetism as a faithful index of the state of the sun it should be understood that not only are there regular ebbs and flows of magnetic force in response to the sun's annual approach and recession, his axial rotation and daily



HARGRAVE-MARVIN BOX KITES.

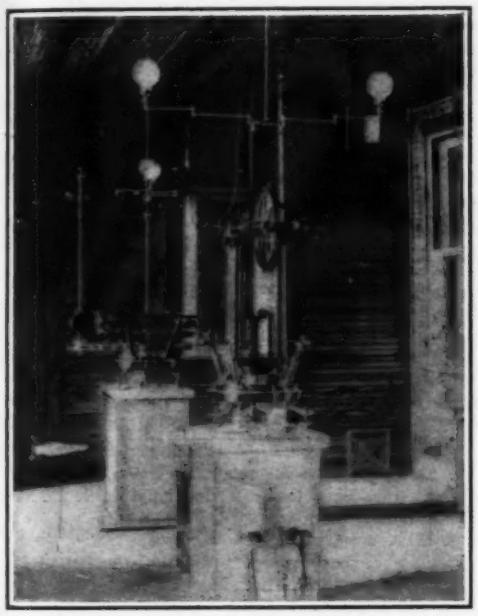
passage through the heavens, but even the outburst of a solar spot is simultaneously announced by a disturbance of the earth's magnetism."

So important to the study of the sun is a continuous record of the magnetic variations that one of the

first steps in the establishment of the observatory was the installation of a magnetic plant consisting of the best modern instruments for the direct observation and for the continuous registration of the variations in the magnetism of the earth. The standard observatory instruments, both for continuous registration and direct measurement, are of the type devised by Wild for the model magnetic observatory at Pavlovsk, Russia. These are supplemented by a set of Eschenhagen magnetographs, the extreme sensitiveness of which peculiarly fits them for recording minute fluctuations of the earth's magnetic force.

The principal application of the results of the observations will be to supplement the direct observations of the sun, and thus to carry on the record of the solar activity continuously day and night in all conditions of weather. Researches will also be carried on to determine the existence and measure the extent of probable direct relations between meteorological disturbances and magnetic variations. The magnetic records will also be specially studied in conjunction with the results of observations of the radio-activity and the electrical condition of the air, particularly during thunder storms and at times of auroral displays, for the purpose of revealing their relation to meteorological conditions.

The physical laboratory is not yet completed, and consequently it has not been possible to undertake



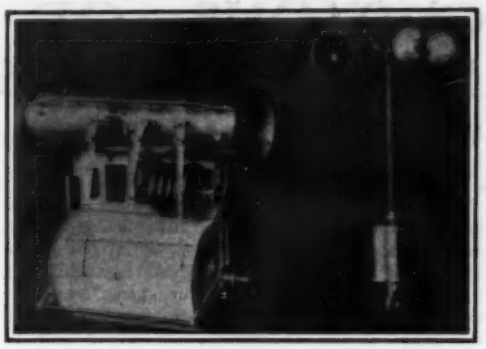
INTERIOR OF MAGNETIC OBSERVATORY—MAGNETOMETER AND INDICATOR.

investigations here in experimental physics. However, through the kindness of the authorities of the University of Virginia a good deal of spectroscopic work has been done at that institution. An investigation, by the aid of a large telescope, of the causes and meteorological relations of the scintillation of stars is in progress at the University of Virginia along lines suggested by one of the Mount Weather officials. A special photometer has been devised for the purpose of measuring the relative densities of clouds, particularly when the entire sky is covered. As soon as the laboratory is completed and equipped investigations will be begun on atmospheric electricity, its origin, distribution, and laws, the causes and nature of precipitation, heat and light absorption, and other physical phenomena of importance to the meteorologist.—Yearbook of the Department of Agriculture.

PRELIMINARY COAL-WASHING TESTS.

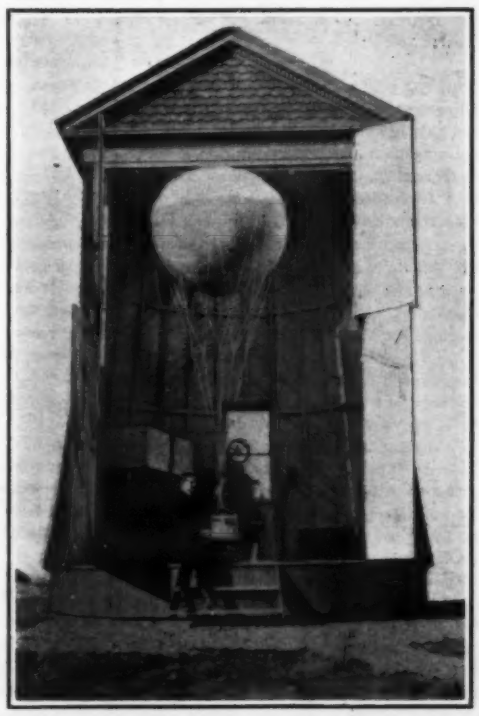
IT is possible to make preliminary tests at small cost, which will prove conclusively just how much a coal may be improved by washing, what the percentage of loss, or refuse, will be, and how fine the coal must be crushed to attain the necessary disintegration, and in fact just how the coal should be treated to obtain the best and most profitable returns. The form of test used in this work is commonly known as a "float and sink" test of which the following is a description:

As it is never advisable to attempt washing of coal of large size lumps, the coal to be tested should first be crushed down to pass through a 2-inch mesh screen. Four or five true average samples, as near as it is possible to obtain, are then carefully dried and weighed, each sample to be as large as can conveniently be handled, say 2 kilogrammes each. Specific-gravity solutions are then provided, one for each sample of coal, and ranging from a specific gravity of 1.35 up, in jumps of 0.05, i. e., 1.35, 1.40, 1.45, etc. Each pan is filled about three-quarters full of its respective specific-gravity solution, and a sample of coal deposited in each. These should then be stirred sufficiently that all pieces of the raw coal are thoroughly covered with the liquid, and so that all pieces of a greater specific gravity than the liquid will sink to the bottom of the pan. All pieces of a less specific gravity will of course float on top of the liquid. It will be readily understood that a 1.50 specific-gravity solution will



MARVIN KITE METEOROGRAPH WITH ANEMOMETER.

"float" more of its sample than will the 1.35 solution. Remembering that the quality of coal decreases with its rise in specific gravity, it will also be readily understood that the "float" on the 1.50 solution will be a lower grade than will be the "float" on the 1.35 solution. The "float" from this test is equivalent to the washed coal in the washer plant, and the "sink" the equivalent of the refuse. To determine their percentages, the "float" should be skimmed off, and the solution filtered to collect all of the fine "float" coal. Both the "float" and "sink" should then be thoroughly rinsed out with water so as to take out all traces of the specific gravity solution used, and then carefully dried and weighed. The variation in the percentages of "float" and "sink" as the specific-gravity solution increases, is equivalent to the variation in the washer plant of the percentages of washed coal and refuse. By analyses of these different samples of "float" coal, the extent of improvement by washing is shown under varying amounts of washed coal and refuse. Now if the limiting percentages of ash and sulphur are known, these tests will show just what percentages of the raw coal must be discarded to obtain a washed coal of this quality, and if the percentage of refuse seems high, and the "sink" equivalent to the refuse contains considerable coal or "bone coal," this "sink" may be tested in a higher specific-gravity solution so as to "float" this bone coal and it can then be analyzed and tested to determine its value for some purpose other than that intended for the washed coal. Of course it may be that none of these tests will give a "float" coal equal to the quality required, or possibly the "float" coal on the 1.35 solution will be satisfactory in quality but of not sufficient quantity to make it a payable proposition. If such be the case then the same tests should be made upon the coal crushed a little finer, and in this way the tests may be carried

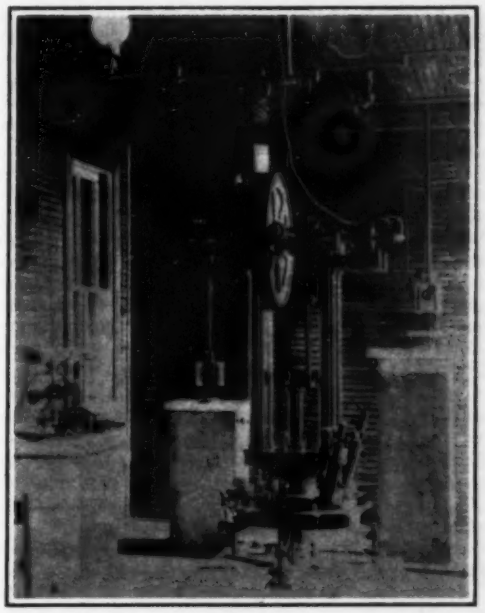


REVOLVING KITE AND BALLOON SHED.

on until the most efficient degree of disintegration is determined and the coal proven either a possible or an impossible coal-washing proposition. It has been the writer's experience that the results of these "float" and "sink" tests can be very closely approached in the actual washing, provided the samples have been properly taken so as to be a true average of the coal as named.—From article "Bituminous Coal Washing," in Mines and Minerals.

SOLAR ENERGY AND SOLAR ENGINES.

THE Electrical World, in referring to a contribution by Mr. W. W. Coblentz to a recent issue of the Physical Review on the probable temperature of the sun and moon, says: It appears that the radiation power of the sun, at the surface of the earth, amounts to about 1.75 kilowatts per square meter of perpendicularly exposed earth-surface. Of this, the books tell us about one-quarter is absorbed in the air, when the sun is at its zenith, or getting in his best work; so that what reaches the earth when the sun is overhead is, say, about 1.3 kilowatts per square meter. In the temperate zones, where the sun is never vertically overhead, the layer of air passed through by the sun's rays is thicker and the absorption consequently greater, especially in early morning and late evening, so that a square meter of surface kept facing the sun all day long during a clear summer day might only receive an average radiation power of about 0.5 kilowatt. Of course, the square meter would reflect away a large proportion of this power, if its surface were of polished



INTERIOR OF MAGNETIC OBSERVATORY—DECLINOMETER AND THEODOLITE.

metal, and even a dull black surface, like that of plumbago, would dissipate convectively the heat which it received, so that it is very hard to catch and utilize this radiated solar power. Nevertheless, if we could employ this power practically and conveniently, we should obtain an immense benefit. Thus, allowing that the noon-day solar power on a bright day was 1 kilowatt per square meter of perpendicularly exposed surface, we should only have to expose a surface of 10 meters square in order to receive 100 kilowatts; and if an efficiency of 50 per cent were imagined in the apparatus, we would be able to develop 50 kilowatts during the brightest part of the day from a disk about 37 feet in diameter.

The only solar engine which has yet been made successful is the waterfall. A fraction of the solar radiation energy reaching the surface of the earth is expended in converting surface ocean-water into steam or water vapor and in raising that steam to an elevation among the clouds. Part of this energy is released in rainfall, and only an insignificantly small fraction of the rainfall occurs on elevated land in such a manner that a waterfall can be made available. There is at least one other type of solar engine possible, and that is a surface of chemical substance exposed to solar radiation and capable of being chemically transformed to a stable substance which will subsequently give up its energy for consumption. A grass meadow supporting horses is a crude form of such a machine. A small fraction of the incident solar energy is usefully absorbed by the chlorophyl in the grasses, permitting them to build up a hydrocarbon structure from an environment of gaseous water and carbon-dioxide. The horses consume and assimilate the grass, and each is capable of delivering a few kilowatt-hours a day of solar energy—an infinitesimal fraction of the total solar energy incident on the meadow. It might be possible to find a chemical substance much superior to chlorophyl as a recipient or storage material, and capable of releasing its energy in an electrical way. The paper shows that the surface temperature of the sun works out about 5,980

deg. absolute or 5,707 deg. C., each square meter of solar surface liberating apparently 67,600 kilowatts or not far from 90,000 horse-power. The effective temperature of the moon on the side facing the sun appears to be about 82 deg. C. This shows how small a share of incident radiation energy a reflector can claim as commission for its duty. The moon is supposed to have little else to do, from a human utility standpoint, than to reflect radiation. She constantly receives a large total amount of radiation power, but is not able to raise her surface temperature thereby beyond about 100 deg. C.

MODERN APPLICATIONS OF SUPERHEATING TO MARINE STEAM-BOILERS.*

THE TESTS AND RESULTS OF THE TWO TYPES OF SUPERHEATERS.

BY ARTHUR SPYER, M. INST. C.E.

INFORMATION on the behavior of superheated steam as a gas is still deficient, and some recent experiments carried out by Messrs. Knoblauch and Jacob at Munich show that the specific heat at any given pressure is considerably higher than hitherto assumed; that it diminishes as the amount of superheat increases up to a certain point, and then rises again; and these results will influence theoretical calculations made in connection with the subject.†

Superheaters which have been applied for marine work may be divided into two classes:

1. Those fitted in the uptake, and absorbing the heat from the gases of combustion after leaving the boiler.

2. Those placed in the boiler in such a position as to absorb heat from the gases during their passage through the boilers.

As to the first type, the largest applications for marine purposes in this country have been made by Messrs. Thomas Wilson, Sons & Co., who in 1900 fitted the "Claro" with superheaters. These superheaters consist of a series of multiple U-tubes, with collectors at the inlet and the outlet. The result obtained in the "Claro" was so satisfactory that the system has been largely extended in the Wilson fleet, and they have at the present moment twelve vessels fitted or being fitted with superheaters.

Owing to the low gas-temperature available a large superheater surface has to be provided, ranging from 40 per cent to 50 per cent of the boiler-heating surface, in order to give a superheat of 90 deg. to 140 deg.

As regards results, the "Aleppo," which has been fitted with superheaters, and runs with an average of about 150 deg. of superheat, has been carefully compared as regards coal consumption on her voyages with two sister ships, identical in other respects, running on similar service and at the same speed, but not fitted with superheaters; and it has been found that the coal consumption of the "Aleppo" is 12½ per cent less than the sister ships over several years of service.

In the case of the "Martello," which is fitted with Babcock & Wilcox boilers, the result has been somewhat obscured by the fact that, when superheaters were fitted, new cylinders were also fitted, and the cylinder proportions were considerably modified from those originally obtaining. The saving was remarkable; the vessel now uses only three of her four boilers, she runs at the same speed on the same service as she did previously, and the coal consumption has been reduced from 44 tons to 31 tons per day. The amount of superheat used in the "Martello" is 90 deg., the surface of the three boilers is 8,055 square feet, and the superheater surface 2,000 square feet.

One of the most important questions is the condition and material of the working surfaces of the cylinders and slide-valves. On this point Messrs. Wilson's experience is of great value, as it is found that there is no trouble whatever. A very small amount of lubrication is applied internally and on the piston-rods. The oil used has the specially high flash-point of 700 deg., does not form an emulsion in the feed-water, and is easily removable by an ordinary mechanical filter.

As regards material of the rubbing surfaces, cast iron is invariably used; piston-valves are fitted in the high and intermediate cylinders, and flat valves in the low-pressure cylinders; and it is found that the wear is in many instances not so much as in ordinary cases. Moreover, there is much less trouble with the piston-rods and glands than where saturated steam is used, and there is less leakage from pipe-joints, etc.

As regards durability, a tube was cut from the "Claro" after five years' service, and no wear could be detected in it; and recently I had a tube cut out from a superheater which has been at work in a boiler on shore for eleven years, and failed to detect any wear in it. This tube is on the table.

The Central Marine Engine Works, of Hartlepool, have also installed several superheaters of type No. 1, one case being that of the "Inchmona," in connection with quadruple-expansion five-crank engines, and a boiler pressure of 225 pounds per square inch.

The superheaters are fitted directly in the uptakes, below the air-heating tubes, and consist of a series of spiral coils, connected at top and bottom by cast-iron headers. The results obtained in the "Inchmona" were so encouraging that the system was repeated in the "Inchdune," "Inchmarlo," and "Nasovia"; and it is stated that the "Inchdune" and "Inchmarlo" have been able to run whole voyages on an average consumption of 1 pound of coal per indicated horse-power hour.

A vessel called the "Teutonic" has also been fitted with superheaters, the superheater in this case consisting of a series of multiple U-tubes.

The economy directly attributable to superheating, from the data in the possession of the Central Marine Engine Company, works out to about 8 per cent; but it should be noted that the total degree of superheat imparted to the steam is only about 70 deg. In the experience of the Central Marine Engine Company, no ill effects have been noticed in the working of the engines due to the use of superheated steam.

As regards the superheaters of the second type—namely, those placed in an intermediate position in the boiler—the only one which has been largely used is the Babcock-Wilcox. There are isolated cases of other systems, such as the Pielock superheater, which has been adopted in an installation of ordinary cylindrical marine boilers in France, in a vessel called the "Larence." In this system the superheater is arranged in the water-space of the boiler, and consists of a steam and water-tight casing inclosing the heating tubes through a portion of their length; the fire gases flow through the tubes of the boiler, thereby superheating the steam which passes round the portion of the tubes inside the casing.

The Babcock-Wilcox superheater is applied in conjunction with the Babcock-Wilcox marine boiler, in which the gases are passed three times through the boiler-heating surface by means of suitable baffling, and the superheater is placed between the first and second passes. By this means a gas-temperature is obtained sufficient to impart a good degree of superheat with a moderate surface in the superheater.

The first tests with this superheater were made in America, on a vessel called the "J. G. Wallace," fitted with boilers of 5,800 square feet and superheaters of 830 square feet of surface. The superheaters were placed in the first pass, but arranged so that by a simple alteration of baffling they might be cut out of the circuit altogether; thus a comparison could be made using the same boilers in the same ship, and without superheaters. The result of these trials is given below:

	Saturated Steam.	Superheated Steam.
Indicated horse-power	1,530	1,559
Coal per indicated horse-power	1.76 lb.	1.51 lb.
Average steam pressure, pounds per square inch.....	238.7	237.6
Main feed temperature.....	192.7 deg. F.	195 deg. F.
Revolutions per minute.....	77	79

From this it appears that the increased coal-consumption due to using saturated steam was 16½ per cent.

A curious thing occurred in these two trials. It was found that when using saturated steam the power was developed with a somewhat earlier cut-off. The reason of this is not very clear, because the same volume of superheated steam should contain sufficient heat to develop the same power, although, of course, the weight would be very considerably less.

Following on the "J. G. Wallace" the American navy made an experiment by fitting superheaters to four out of the eight boilers of the "Indiana." The results were not published, but that it was favorable is certain from the fact that since then superheaters have been ordered for four other American warships.

There are now under construction two sister ships of the "J. G. Wallace," fitted with superheaters, and also a vessel named the "Creole." This latter, when complete, will be of special interest, as the vessel is fitted with Curtis turbines, working at 250 pounds pressure. The principal particulars of this installation are as follows:

Indicated horse-power	7500
Heating surface in boilers.....	28,150 sq. ft.
Heating surface in superheaters..	4,350 "
Grate area	783 "
Number of boilers	10

Recently the Admiralty decided to fit superheaters to six of the boilers in H.M.S. "Britannia." A boiler fitted with superheater was erected in the test house at Messrs. Babcock & Wilcox's works at Renfrew, and four trials were made at rates of coal consumption varying from 14 pounds to 30 pounds per square foot of grate per hour; and a noticeable point in the trials was the constancy of the superheat, which varied only from 75 deg. to 91 deg. This is of importance, as for navy purposes the rates of working vary considerably; and it is therefore necessary that the superheaters should be so designed that the superheat obtainable should be as nearly as possible constant.

A series of tests were carried out by the Admiralty on the official sea trials of the vessel. The first two trials were of special interest, as in one case six boilers were used without superheaters, and in the other case six boilers with superheaters. The results obtained are as follows:

	Six Saturated Steam Boilers.	Six Superheated Steam Boilers.
Indicated horse-power.....	3,521	3,410
Coal per indicated horse-power, lb..	2.07	1.77
Water per indicated horse-power, main engines, lb.....	16.98	13.65
Water per indicated horse-power, auxiliary engines, lb.....	4.1	4.56
Total, engines.....	21.08	18.19
Steam pressure in boilers, lb. per square inch	190.3	200
Superheat at boilers, deg.....	.....	92%
Superheat at engines, deg.....	.....	88
Feed temperature, deg.....	72	65.6
Water per square foot of heating surface, actual.....	5.5	5.17
Coal per square foot of grate.....	17.6	14.5
Temperature in uptakes, deg....	398	347

In reference to these trials a curious feature appeared. Apparently the water consumption in the auxiliary engines was increased from 4.1 pounds per indicated horse-power using saturated steam to 4.56 pounds per indicated horse-power, using superheated steam. The reason for this is not clear, as the auxiliary engines, which are most of them of the simple expansion type, are just those which should show a considerable gain in economy when using superheated steam.

A trial was also made at 7,000 horse-power with the same two groups of boilers at work, one set on the starboard engines, the other on the port engines. The engine water consumptions were 13.26 pounds per indicated horse-power with superheated steam, against 15.01 pounds with saturated steam, each engine developing 3,500 horse-power. The uptake temperature recorded was 346 deg. for the superheater boilers and 370 deg. for the saturated steam boilers.

On the subsequent trials of the "Britannia," at 13,000 horse-power and at her full power of 18,000 horse-power, the boilers with superheaters showed a lower uptake temperature than those without superheaters; at 13,000 horse-power the difference was 20 deg., and at 18,000 horse-power it was 7 deg.

Experience, therefore, would appear to show that with reciprocating engines, when properly adapted for the use of superheated steam, a high degree of economy is obtainable, and that no detrimental results arise from its use. There is apparently no reason, seeing that turbines can be constructed to use superheated steam satisfactorily for land purposes, why they should not also be constructed to use superheated steam for marine purposes; and developments in that direction would appear to be the next step, as already indicated in the American vessel "Creole," with Curtis turbines.

There are, I believe, some other owners who have used superheaters for marine work, but there is, unfortunately, not any information available as to the experience obtained with them; and I can only hope that this brief indication of some of the results actually obtained with superheated steam for marine purposes may be of interest.

* Paper read at the Engineering Conference of the Institution of Civil Engineers, Section V., Shipbuilding.

† Similar experiments are being carried out at the National Physical Laboratory, and they confirm the German results.

Removal of Water Spots from Tracing Cloth.—Water spots can be removed from tracing cloth (according to the Tischler Zeitung) by first spreading flour on the spot and then rubbing it with the finger, dipped in turpentine, until the spot has disappeared. The solid paste is wiped off with tissue paper and the place smoothed with a fine linen cloth, or dilute gum arabic solution is brushed over it. A previous trial, with a piece of no value, is advisable.

THE INTERCHANGE OF HEAT IN STEAM ENGINE CYLINDERS.*

ITS LOSSES UNDER VARIOUS CONDITIONS OF ACTION.

BY W. F. CLEVELAND.

THE theory of the interchange of heat between the working steam at its varying degrees of pressure, humidity, and temperature, and the internal surfaces of the cylinder walls and pistons, has been the subject of much controversial discussion; but its corollary of condensation losses, however fallaciously deduced, is generally accepted as the method by which these losses—the most serious of all in the application of steam power—are sustained.

Objections to the theory have been raised on the ground of the inadequacy of the time afforded during a fraction of the piston stroke, when passing the point of release, where the losses are said to be chiefly incurred; but in presenting this argument a proper association of the facts relating to the action of the heat under common and familiar conditions seems to have been neglected. At three hundred revolutions per minute, or for locomotive engines with six-foot drivers a speed of a trifle over sixty miles per hour, the entire stroke of the piston is covered in one-tenth part of a second, but during the first and a portion of the second quarter, according to the location of the cut-off, the absorption of heat by the metal surfaces from the entering steam must first take place; and as there is little space for expansion earlier than the point of half stroke, the outflow of heat must necessarily occur during the latter half stroke, or at most in one-twentieth part of a second. If, as claimed, the losses occur chiefly when passing the point of release, the time must be still further reduced to perhaps the fiftieth part of a second.

If, in this discussion, we were concerned with electric instead of thermal currents, the importance or bearing of the element of time could not be so intelligibly considered. A naked finger may with impunity be quite slowly passed through a gas flame, but no sane experimentalist would approach a "live wire" with a similar intention. The flesh of the human body is a good conductor of heat, and the temperature of a gas flame is many times greater than that of steam, as used in locomotive boilers; but the significance of these facts may be still further emphasized by varying the experiment by the use of a common friction match or strips of paper, which may be slowly passed through the flame without ignition. The sensation occasioned by a single passage of a finger through the flame is very slight, but although the surrounding atmosphere has the cooling effect of air currents afforded by the alternate passage of the finger through it, there is a gradual accumulation of heat which becomes unbearable at the nail after about thirty-five passages. Matches and small rolls of paper ignite in about the same time. These facts cannot be harmonized with a theory based on the assumption of the rapid flow of heat currents.

In a standard locomotive cylinder using 180 pounds initial pressure there is a range of temperature, between admission and exhaust of about 139 deg., the falling temperature accompanying the pressure, at the point of cut-off, in its gradual descent throughout the expansion curve, but dropping suddenly in unison at the point of release, where the heat stored in the surfaces of the cylinder walls and piston is said to be suddenly transferred in the minute fraction of a second to the escaping steam, and lost in the exhaust. It is therefore assumed that a rapid outflow of heat takes place, similar to that occasioned by the sudden plunging of red-hot metal into cold water; but everyone is familiar with the fact that heat will not flow so rapidly, even in such an experiment, as small strips of heated metal may be suddenly immersed and withdrawn, say one-quarter of a second of time, with but little change of temperature.

A law of heat on which the economy of steam boilers is based permits the flow of heat from iron to water, or aqueous vapor, much more readily than the reversal of the current, and imposes another difficulty in the way of the acceptance of this theory.

If the metal surfaces of the internal parts of the cylinder are robbed of their heat during the period of initial exhaust, their restorage must take place during admission, and the time is therefore almost equally limited; but if the flow of thermal currents into metal surfaces is so slow under analogous conditions, and with such enormous ranges of temperature, the conclusion is inevitable that the internal surfaces of the cylinder parts, already raised to the temperature of boiling water, cannot absorb from steam at a fraction of the temperature of molten iron, or communicate thereto, a much greater volume of heat in a fraction of the time.

In order to avoid the branding of the theory as self-evidently absurd, it must be contended that only a very thin shell of the internal surfaces, say to the extent of five or ten pounds of iron, is thus subjected to changes of temperature; but under this assumption another difficulty is encountered in the limited volume of heat units that could be absorbed and discharged within the claimed fraction of the total range of temperature of 139 deg.

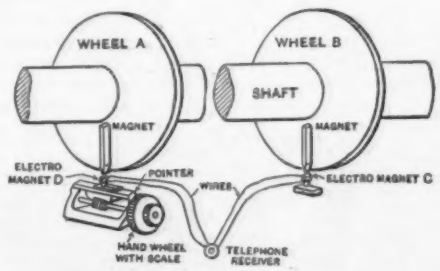
It is contended that the water of condensation and vapor in the working steam flashes into true steam with the sudden reduction in pressure at the point of release, the implication being that with the corresponding drop in temperature that ensues at the same instant, an outflow of heat from the metal surface is induced thereby; but the fact that this very change transforms the absorbing agent from the strongest to the weakest of conductors, is not advanced as a factor in the argument. The boiling point of water, within certain limits, is dependent upon the pressure, but at the point of release the volume of heat units to be discharged cannot act upon the water of condensation, within the cylinder spaces, unless there is an instantaneous or free expansion instead of a prolonged discharge of the exhaust. The immediate effect of such re-evaporation would be the complete drying of the cylinder walls and spaces, but the standard cylinder is unable to free itself from the aqueous residue of the exhaust, which condenses upon its walls, filling the space before the piston, and is swept into the clearance spaces, where it is recharged with heat from the entering steam, to be followed by the endless repetition of wasteful discharge at the point of release. That metal surfaces continually subjected to the action of water under such conditions, in the course of a few revolutions would reach and retain an average temperature, dominated by that of the water with which they are sprayed, partakes strongly of the character of a self-evident truth. It is the water of condensation, acting directly upon the entering steam, that is the real agent of these so-called interchange-of-heat losses, although, properly speaking, there is no interchange of heat; it is merely absorption during admission and discharge during exhaust. The enormous heat-absorbing capacity of aqueous vapor is well known, but this baleful characteristic is aggravated, by the facility afforded for its action, in the thorough mixture of the products of compression with the entering steam.

* Abstract from an article in The Engineering Magazine.

TORSIOMETERS AS APPLIED TO THE MEASUREMENT OF POWER IN MARINE TURBINES.

By ARCHIBALD DENNY.

THE writer, in this article, describes the difficulty met with in measuring the horse-power delivered by the steam turbine. The approved method of gaging the power delivered by reciprocating engines is by computing it from indicator cards. This is manifestly impossible with the turbine. In small machines the power may be absorbed by the Prony brake or some equivalent mechanism, and thus weighed; in direct-



TORSIOMETER APPLIED TO THE MEASUREMENT OF TURBINE POWER.

connected electrical units the power output may be calculated from the readings of the voltmeters and ammeters. In larger machines, however, and particularly in the case of the marine turbine, none of these plans work. The engineers connected with the writer's firm finally hit upon the plan of using the angular flexure of the shaft, as measured between two definite points in its length, as a measure of the torque transmitted. Knowing the torque and the revolutions per minute, the horse-power could be obtained directly.

The cut shows the first practical solution. Two gun-metal wheels *A* and *B* were fastened to the shaft at a definite and known distance apart, the distance being as great as possible. On each wheel a permanent magnet, with a sharp chisel-shaped edge, was fixed radially at the periphery of the wheel, and with the sharp edge parallel to the shaft. At one end a soft iron electro-magnet *C* wound with fine wire, similarly chisel-shaped, was fixed, so that the moving magnet passed directly over the electro-magnet once in each revolution. At the other end a similar electro-magnet *D* was mounted on a threaded sector, and wires from these electro-magnets were led to a differentially-wound telephone receiver. If the shaft revolved without transmitting power, the permanent magnets passed these electro-magnets simultaneously, and currents of electricity generated in each coil passed through the telephone receiver, but the currents being equal and opposite no sound was heard. When the shaft transmitted power, the permanent magnets passed the electro-magnets at different times, and hence a sound was heard in the receiver. By turning the hand-wheel shown in the diagram, a new position of silence could be obtained, when it was evident that the two permanent magnets were again passing the electro-magnets simultaneously, and the amount of torque could be ascertained from the reading of the sector screw.

A later development of this idea was devised which allowed the measurements to be taken in a quiet cabin in any part of the ship instead of necessitating the operator's presence in the more or less noisy shaft tunnel, where there was some possibility of error in interpreting the sounds in the telephone receiver. This method retains the chisel-shaped magnets, but replaces the electro-magnets with a pair of specially wound "inductors" under each wheel, these inductors being so arranged as to permit different portions of their arcs to be active, giving thus the equivalent of shifting the electro-magnet *D* by the hand-wheel. This shifting of the active portion of the inductor is done by switches in the operating room, and does not require the presence of the operator in the tunnel.

The original solution of the problem, earlier than that shown in the cut, was by the obvious method of using on the disks contact points, which struck a fixed point in place of electro-magnet *C*, and an adjustable magnet point in place of electro-magnet *D*. As each contact came around, the circuit was closed, and a sharp click was heard in the telephone receiver. When the hand-wheel was so adjusted that the clicks were simultaneous, the amount of distortion would be read from the graduated disk. While this worked very well on the factory line shaft where it was first tried, at a speed of about 120 revolutions per minute, it failed to be of any use in taking measurements on the side shafts of the "Queen Alexandra," where the speed was over 700 revolutions per minute. Under these circumstances no certain sound could be obtained. It was impossible to be quite sure of the exact point at which the make and break took place, so that the apparatus was useless.

The testing of the shaft to get the torsion scale, previous to its being fitted on board, is done by fixing rigidly one end of the length of the shaft to be used for the trials, and at the other end fitting a lever; this is loaded with weights so as to get the scale or torsion moment. For turbine shafts, which are small in diameter as a rule, this is not a serious operation; nor, indeed, have we found it so even for larger ordinary twin-screw shafts, although, of course, the weights used have to be much greater. We have tested all the shafts for the turbines and other vessels on which we have used these instruments, and we find that the torsion is given very closely by the following formula:

$$\theta \text{ deg.} = \frac{W R L}{K d^4}$$

where

θ deg. = angle of torsion in degrees.
$W R$ = foot-pounds turning moment.
L = length of shaft in feet.
d = diameter of shaft in inches.
K = coefficient.

K may be taken at 140 for mild steel shafts where there are no couplings, or, if there be any, by deducting their length from the length of shaft twisted; that is, we assume that the couplings do not twist. It is, of course, better to test each shaft independently, but the error would not be great by using the formula, probably not one per cent either way.—Mechanical Engineer.

DIFFERENT TYPES OF ICE HOUSES.

THEIR CONSTRUCTION, VENTILATION, AND ECONOMIES.

BY A. S. ATKINSON.

IN my experience with icehouses I have found that as a rule the builder generally overestimates the size and capacity for any given purpose. A large icehouse is a white elephant on the hands of an owner of a private country home, for it cannot be economically filled, and if not properly filled the waste of ice is very great. Moreover, many people are deterred from having an icehouse built on account of the initial cost. If you can show plans to a householder which call for an expenditure of $100 to $200 for a serviceable icehouse he is very apt to order its construction, but if the cost is to be $500 and upward he will hesitate.

Good, serviceable icehouses can be put up for $100 to $200 suitable to the needs of a family who wish to carry enough ice to last through the year and no more. Ice left over in such a private house is wasted. The great trouble with many builders is that they cannot figure on the capacity of a house for an ordinary family, and, therefore, to make allowances for a surplus, they plan big, barn-like structures. It may not be amiss then to say something about the needs of a family in the way of ice. For the ordinary family of four to six people, who use ice daily and freely winter and summer, a house with inside measurements of 8 x 8 and 8 feet high will hold all the ice needed. This, of course, presupposes such proper construction that the ice will not melt. Many country homes would be supplied with such small, compact icehouses if they understood their capacity and suitableness, and, above all, their low cost. Such an icehouse can be put up from $100 to $150, depending upon cost of labor, lumber and cement.

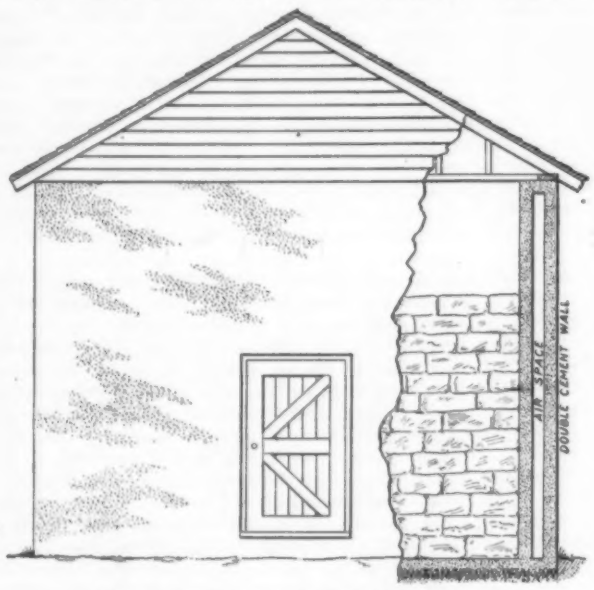


Fig. 1.—Ice House of Cement Construction.

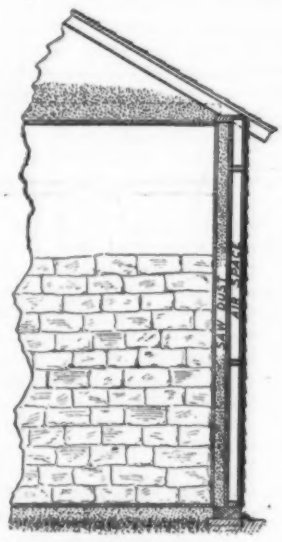


Fig. 2.—Section of an All-Timber Ice House.

Another family keeps a number of cows and must, therefore, have some room for cooling and keeping the milk. This requires a larger house, for the extra ice taken for the dairy purposes must cut deeply into the supply. A house 12 x 14 and 10 feet high will hold sufficient ice for such a family. A number of houses of this size are used by small fruit and dairy farmers, and they never run short of ice during the warm season, as they economize in the ice used during cold weather. But a good-sized dairy farm, where ice is to be used both for the house and the cooling of milk, should have an icehouse about 14 x 16 and 14 feet high. This should have a capacity suitable for all the needs of the business. The cost of an icehouse of this character should not run higher than $300, and of the other size not more than $200 to $250.

After one has decided on the size and capacity of the icehouse the question of type should be reached. The old-fashioned high icehouse, with an elevator, is no longer to be recommended. We see many of these along the Hudson River's banks, built for commercial purposes, but they have great disadvantages. The ice melts faster and it costs more for labor to fill them. A low, compact icehouse is always the most economical, and the least objectionable in looks. Likewise the old-fashioned underground icehouse is not in favor. In this type the excavation made was deep enough to hold all the ice, and the only visible part above the ground was the peak of the roof, with a door on one side. Such houses were constructed in the days when it was thought that it was essential to bury the ice underground to keep it from melting. Modern methods of building icehouses, however, make it possible to carry the structure up to almost any height with a minimum loss of ice through melting.

The most popular and typical house of the day is made of wood, with properly constructed walls and floors, and with only a fair elevation above ground. The grout cement icehouse is popular on account of its great durability in localities where suitable stones are plentiful and cheap. The walls are constructed of stones, which are bound together by cement and gravel. The only wood used in its construction is for the roof, doors, posts for foundation, and inside boards. A double row of posts are placed inside to hold the stones and cement in position, and inside of these boards are placed. A wall a foot or more thick is formed by these boards, and the space between is filled with smaller stones. A mixture of 1 part of cement to 4 or 5 of sand is then poured in this space until the grout is firmly bound together. In order to simplify the building, the boards can be placed up in sections, and the walls thus run up to the desired height without trouble. When the walls are finished a plate is put on the top, and a peaked roof constructed in the ordinary way. The space left for a door is framed with wood. An inside and outside door with a space between helps to keep the ice from melting, and prevents a rush of outside air when frequently opened. To accomplish this a small wooden vestibule may be built in front, with the outside door opening from it. This feature is not necessary, however, except where the icehouse is to be frequently opened.

Where stones are plentiful this form of icehouse is the cheapest that can be constructed. Hundreds of them have been built for $100 and less. A good one suitable for a large family, 12 x 14 x 8, can be constructed for $100, with cement at $1 per barrel. Fifteen barrels of cement would be sufficient to grout the walls properly and $20 worth of lumber, $14 for shingles and $5 for posts and joists, should cover the material. The cost of sand and hauling the stones should not exceed $20 more. The labor item is an indefinite problem, so much depending upon the cost in various localities. But with labor of a first-class man at $2.50 per day, and a helper at $1.50, the work should be completed within 10 or 12 days. This will bring the whole cost of the icehouse to about $100.

As an improvement upon the grout icehouse the all-cement type has been built in recent years in many parts of the country. Such a house will cost nearly double, however, on account of the greater amount of cement used. Double walls can easily be made with cement and a double wall is always a great money saver in icehouses. The appropriate mixture for such a house is one part cement to two parts clean sand and four parts of small broken stone. About 30 barrels of cement will be needed for a house of the size described above. The excavation should be carried 5 feet below the surface and 16 inches should be allowed for the walls. A layer of broken stone, followed by one of coarse sand, well pounded down, should form the floor, and over this a good mixture of concrete should be spread.

The walls are formed by making boxes for every foot-section with boards. The walls should be 3 inches thick with a 10-inch space between. A layer of galvanized iron flat strips should bind the inner and outer wall together every other foot-section up. The ends of the bonds should be turned in to give greater strength. After each section has hardened the forms can be removed and used for the section above. If the bottom and top of the walls are filled in solid with cement the air space will have no outlet for the air to circulate. The roof is made of wood and should be slanting to shed the rain, the eaves projecting a foot beyond the walls. The roof should be double, like the walls. An idea of the construction followed is shown in Fig. 1.

The wooden icehouse is popular in lumber districts where stones as a rule are not so easily had. It is the oldest type of house, but in its modern form it can be constructed at little real expense. If properly built it is not even necessary to make any great excavation, and its foundations need not be more than a few feet below the ground. A good depth, however, for the excavation is 5 feet, leaving 1 foot for the stone and cement floor. The foundation up to a level with the surface should then be made of loose stones as carefully as possible, with cement or mortar to bind them together where needed. A good foundation, such as used for an ordinary barn, will suffice.

On the top of the foundation 8-inch chestnut sills should be laid. The studding should be placed on the sills 2 feet on centers. The best size of studding for an ordinary icehouse is 2 x 6 inch. The corner posts can be made a little larger or of the same dimensions, nailed together in the ordinary way. A cheap frame icehouse consists simply of an inside and outside wall of boards with a 3 or 4-inch air space between. The outside is covered with sheathing and the inside with ordinary boards, new or second hand. If the boards are not well matched an inside sheathing of builder's paper will make the walls air tight. The roof should be carefully adjusted so that as little rain as possible can enter. It is necessary that a free circulation of air be provided under the roof, and the space above the plate and under the rafters must be left open and free. A timber icehouse of this type, with an air space between the wooden walls, and measuring inside 14 x 16 x 14, can be constructed at a total cost of $150, where unmatched lumber costs $20 a thousand and siding $28 and shingles $4.50 per thousand. If labor can be had for $2.50 per day, with assistants at $1.50, the cost may be slightly less. About 20 days' labor for one man should be allowed for the construction, or 10 days for two. Variations in the labor market must always be a factor that cannot easily be figured upon for any locality in advance, and while such a house may be built for $150, an estimate of $200 should be made to protect the builder. This, of course, makes no allowance for his own profit, and the cost to the owner must be somewhat higher. The figures are close enough to guide a contractor in making an estimate. Very few householders would hesitate to order such an icehouse if they could be assured of its construction at a cost of $300 to $400.

A more complete and costly icehouse is shown in part in Fig. 2 of the illustrations. This includes an inside space packed with sawdust in addition to the air space between the boards. It makes the house doubly protected from outside changes of the atmosphere, and makes it possible to keep ice right through the hottest summer. Where the ice is to be used for dairy purposes a doubly protected icehouse of this character proves more permanent and satisfactory. The extra cost is more than paid for in the long run.

A rather larger sill is needed for such a house, but 2 x 4 studding will do. Like the other house the outside is covered with good siding and the inside with unmatched lumber. The air space is left between the inner and outer walls. Now a foot inside of the inner wall a row of studs are erected, and boarded up, forming a crib for holding the sawdust. The sawdust is packed in this crib. The icehouse is thus protected by the air space and the sawdust packing. In extremely hot summers the sun's rays will sometimes warm up the confined air and this will raise the temperature inside. But if this outside air comes in contact with the sawdust packing it will not have much chance to affect the interior of the icehouse. The extra cost of making this double protection is simply for labor and unmatched lumber. At the most it should not amount to more than $75 or possibly $100, in some localities.

In all icehouse construction the cardinal principles of its purposes should be kept well in mind. The first consideration is that the ice must be protected from the outside air. If a current of outside air comes in contact with the ice it will quickly melt it, and any type of house which permits this will not answer the purpose. It may be elaborately constructed and contain a good deal of fine carpentry work, but it will

prove inefficient. All of the different methods of construction, therefore, aim to accomplish this one particular object. When an icehouse is frequently opened to remove pieces of ice the inrush of outside air causes more of the ice to melt than many imagine. For this reason it is essential that the top of the ice should be protected by a layer of sawdust, and if possible, no part of it should be exposed except the cake that is to be removed.

Another point that may be frequently overlooked is the need of perfect drainage. Some of the ice will melt, and as a consequence the water accumulates at the bottom. Ice standing in water will quickly melt, no matter how well the inside is protected from outside air currents. The cement or gravel bottom of the icehouse must, therefore, be able to carry away the moisture. If a cement bottom is used it must slope toward one side or in the middle, where a drain pipe is installed. If only loose stones and sand are used for the bottom the drainage is natural between the interstices. Care must be taken in selecting the site to see that this drainage can be carried away. If the soil is thick it may be necessary to lay a soil pipe to conduct the water away from the foundations. Good drainage can be had in thick soil by digging a hole in the middle or corner of the foundations and sinking an old barrel. The barrel is then filled with loose stones and the drainage carried into this.

It is more important to have the bottom of the icehouse amply protected from outside air than the top. The ice in the bottom of the house must be used last, and for this reason it needs the most protection. It is possible to make an icehouse too tight—that is, under the roof it may be so tight that there is no circulation of air. The result of this is that moisture collects inside and causes loss. The roof is simply to protect the house from rain and sun. Underneath it there should be good air ventilation. This will absorb the moisture and carry off foul air. Ventilation in the roof should be provided so that it can be increased or decreased to suit the conditions of the weather and ice. When the interior is damp it is a sign that there is not sufficient roof ventilation. Cool, dry air is the great consideration, and if this can be obtained the ice will keep indefinitely.—Carpentry and Building.

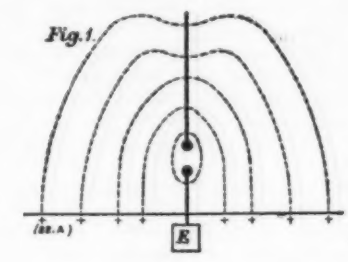
RECENT CONTRIBUTIONS TO ELECTRIC WAVE TELEGRAPHY.

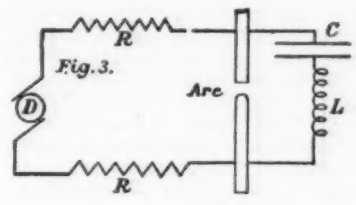
AN INTERESTING DISCOURSE BY PROF. FLEMING ON THE RAPID ADVANCE IN THE COMMERCIAL APPLICATION OF WIRELESS TELEGRAPHY.—FURTHER PROGRESS DEPENDENT ON EXACT MEASUREMENT OF ELECTRIC WAVES.

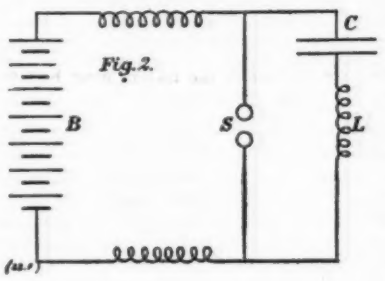
A LECTURE was recently delivered at the Royal Institution by Prof. J. A. Fleming, F.R.S., who took as his subject the recent advances made in wireless telegraphy. In commencing his address, Prof. Fleming said that, though hardly more than ten years old, the system of wireless telegraphy by electric waves had developed immensely in its practical applications. It had proved extremely useful as a means of communication in naval warfare, and had at the same time been of much service to the ocean traveler, the passenger ships of all the great trans-Atlantic lines being, by means of the noiseless far-reaching voices provided by electric waves, never out of touch with land, from port to port. Ships fitted with long-distance apparatus might, in fact, be simultaneously in touch with the Marconi station at Cape Cod and with Clieveden, in Ireland, or Poldhu, in Cornwall.

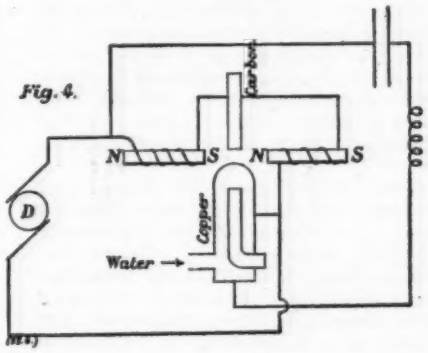
Every important navy had adopted the system in some form or other. With respect to the British, he was informed by Admiral Sir Henry Jackson that nearly all the first and second-class battleships and cruisers were fitted up with wireless telegraphic plant, which had proved so useful that it had been decided to fit it to every vessel larger than a torpedo-boat, fairly powerful apparatus being provided in the case of large battleships. At the same time over a hundred commercial vessels had been fitted with the Marconi apparatus. Concurrently with this practical development of the method there had been a corresponding advance on the scientific side. As in other cases, a stage was reached in which exact measurement was necessary to indicate the lines along which further progress was possible. In the case of wireless telegraphy, the things to be measured would be best comprehended by considering the nature of the phenomena involved. At each electric wire station there was an antenna which, in the case of a small station, might be a simple vertical wire, while in the case of a large one it might consist of 20 to 30 miles of such wires upheld by lattice towers. At the sending stations the antenna was the seat of electric oscillations which gave rise to waves in the surrounding space. These waves fell on the antenna at the receiving station, and reproduced in it electrical oscillations, which could be detected by suitable means. The state of the antenna and the space around it, previous to the passage of a spark, could be represented diagrammatically as in Fig. 1, lines of electric strain extending from the wire to the ground. When the spark passed these lines of strain were released; but in virtue of inertia the released electrons rushed to and fro along the wire in a series of oscillations. In so doing they set up a magnetic field around the wire, the direction of which was reversed at each oscillation. The point of reversal of this field spread out through space with the speed of light, and was accompanied by loops of electric strain, having their feet resting on the ground. The distance between the maximum values of successive loops was known as half a wave-length. The power which the waves possessed of passing round obstacles depended upon this wave-length.

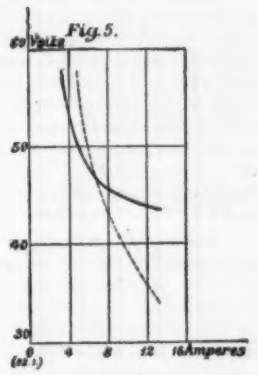
Electric wave telegraphy, he continued, formed a portion of the great science of radiation, which included optics and spectrum analysis, the fundamental laws of which were the same as for wireless telegraphy. In all cases of wave motion the relation $V = n \lambda$ held, where V denoted the speed of propagation, n the frequency, and λ the wave-length. Hence, if the periodic time of the vibration could be determined, the wave-length was also known, as V was, in the case under consideration, the velocity of light. The plan followed was, therefore, to bring near the emitting circuit, which had both capacity and inductance, another circuit having a variable inductance and capacity. These were altered till the two circuits were in tune, and it then followed that the product of the inductance and capacity was the same for both cir-

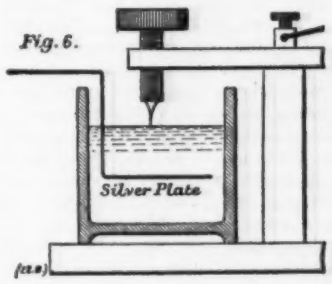


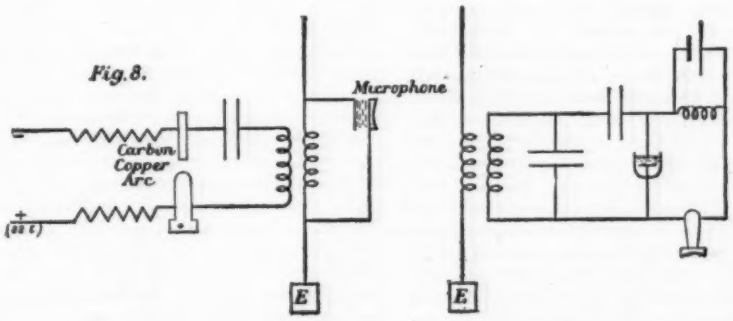


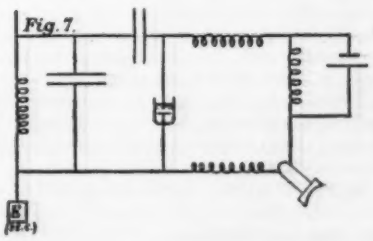


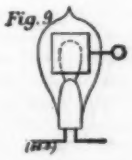


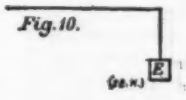


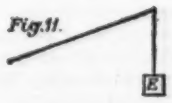












cuits, in which case the periodic time was given by the relation

$$t = \frac{\sqrt{C\,L}}{6{,}000{,}000}$$

where C and L were respectively the known capacity and inductance of the secondary circuit. An instrument devised by him for the above purpose he had named a "cymometer." The inductance was provided by a long wire wound spirally, and the capacity by two tubes separated by ebonite, one of which could slide over the other. As a means of detecting when the two circuits were in tune, he used a vacuum tube filled with neon, which was connected to the terminals of the cymometer and glowed brightly when resonance was obtained between the two circuits, the indication being very sharp. These instruments, he said, were now made to measure wave-lengths ranging from 200 feet to 20,000 feet.

The cymometer, he continued, might also be used to measure the decrement or damping of the waves. The waves emitted by an antenna fitted with a spark-gap died away gradually, each successive wave having less amplitude than its predecessor of the same group. The ratio of the amplitudes was the same for each successive pair of waves, and was called the "decrement." If this were known, the total effective duration of the group could be calculated; that was to say, the time in which the amplitude had diminished to 1 per cent of its initial value. Waves might die out rapidly or slowly, and it was also possible to produce undamped or persistent waves. In using the cymometer to determine the decrement, a very sensitive ampere-meter, formed by a thermopile, was introduced into the cymometer circuit. This done, it was easy to plot out a curve, showing the relation between the natural frequency of the cymometer circuit, as its inductance was varied, and the strength of the current observed. After adding a small resistance to the circuit a second curve of the same kind could be determined, and from the two it was possible, as shown by Bjerknes and Drude, to determine the damping factor for the primary circuit. The amplitude could also be obtained, so that by means of the cymometer the wave-length, the number in the train, and the damping factor could be found.

Various kinds of transmitting circuits had been used in wireless telegraphy. In general the aerial was charged by inductance, and then it might be either "closely" or "loosely" coupled with the primary, and as a result, the oscillations emitted might be strongly or feebly damped. In the latter alternative each train consisted of many oscillations, and thus it was easier to get resonance in the case of the receiving circuit. Several methods had, Prof. Fleming proceeded, been proposed for getting an undamped train of waves. Thus a small alternator had been used by Mr. S. G. Brown. This ran at 6,000 revolutions per minute, and gave waves with a frequency of 12,000 per second. The total power of the machine was, however, only 50 watts. It was, however, necessary in wireless telegraphy to have either a high frequency or a large power. With a frequency of 10,000 per second the waves would be 100,000 feet in length, and very expensive antennæ, absorbing large power, would be required. Tesla, Elihu Thomson, Duddell and Fessenden had all experimented along this line; but he believed that the highest frequency yet obtained from an alternator was 50,000 per second, and the power put into the circuit was small. The next method he would consider was the electric arc as a source of undamped waves. As in many other cases, this application had been foreshadowed by a sort of twilight before the dawn. Thus Elihu Thomson, in 1892, had, as represented in Fig. 2, shunted a spark-gap with a condenser, and observed that a high-frequency current was obtained in the condenser circuit.

In 1899 or 1900 Duddell had shown that if an arc lamp was shunted by a condenser and inductance, as in Fig. 3, a high-frequency current was again obtained round the condenser circuit. In 1903 Mr. Poulsen had made a further advance by making the arc between a carbon and a copper rod, the latter being cooled by water, and the whole arc surrounded by an atmosphere of hydrogen. At the same time a strong magnetic field was established across the arc, as indicated in Fig. 4. In this way a much higher frequency was obtained. This method of producing undamped trains of waves was highly interesting and very important. It had been the subject of much investigation in the speaker's laboratory, where, at his (Dr. Fleming's) suggestion, Mr. Hudson, one of his research students, had determined the relation between current and potential for a carbon-metal arc. This had already been done for the carbon-carbon arc, and it was found that potential fell as the current increased, a fact which was sometimes expressed by stating that the arc had a negative resistance; but he himself preferred to say that it had a falling characteristic curve. In the case of the metal-carbon arc this droop in the characteristic was much more marked, as would be seen on reference to Fig. 5.

He had, the speaker continued, a Poulsen arc on the table. The arc was inclosed in a brass box kept filled with coal-gas. The capacity in the circuit was small, merely 1/300 microfarad, or that of a large Leyden jar, while the inductance was large. As antenna he would use a long wire helix which had a natural periodic time equal to 1/200,000 second. The impulses from the arc must, he proceeded, be supplied at exactly this rate, and when this was done, strong electric brushes appeared at the terminals of the helix, while all around it was an intense alternating magnetic field. The waves emitted in this case were about a mile in length. With this apparatus Dr. Fleming showed many beautiful experiments. Every kind of vacuum tube glowed highly when brought near the helix, especially fine results being obtained with those containing neon, which gave quite a brilliant light. It was, however, he said, an uneconomical method of lighting, as the apparatus took about 3 horse-power to work it. Tubes containing rarefied air also lit up, and soon became very hot, as the quantity of electricity oscillating to and fro in them was very considerable.

With the neon tube, he continued, several important points could be established. In the first place, the great accuracy of tuning required; as a change of an inch or two in the position of the slider constituting the variable inductance in the primary circuit caused the glow to vanish, and a similar result followed when the lecturer brought his open hand near the helix, and thus slightly increased its capacity. By mounting a neon tube on a rotating axis he further demonstrated that the Poulsen vibrations were not quite continuous, as dark bands then became visible in the glowing mass formed by the rotating tube, showing that at certain points the light vanished. He had, he said, been trying to find a reason for this lack of continuity in the Poulsen oscillations, and it was, perhaps, partly due to a lack of uniformity in the speed with which the carbon member of the arc was rotated. This was done by an electromotor, and had to be effected with great smoothness. The brushes visible at the end of the helix he showed were actual flames, capable of lighting a piece of paper.

The question might arise, he went on, as to how the large currents in evidence were produced in the helix. This was effected in much the same way that a theater manager managed to represent on the stage a large army by marching to and fro a party of 50 supers. Similarly, the large current in question arose from the passage to and fro of a small quantity of electricity. A 50-volt lamp connected to the terminals of the helix glowed brightly. Placing a coil of thirty turns of copper wire near the helix, Prof. Fleming next showed that the currents induced in this could be transformed down. This was accomplished by bringing a coil consisting of a single turn of stout copper, short-circuited by a piece of fine iron wire, near this thirty-turn coil, when the iron first glowed red, and finally melted.

As to the theory of the musical arc, it had, he said, been likened to that of the organ pipe, in which the passage of air, through the opening, set up and maintained a set of stationary waves in the rest of the pipe. In the same way, when a condenser was put across an arc it first robbed the latter of current. This caused the potential difference across the arc to rise and more current to flow into the condenser. The latter next began to discharge back across the arc, and as the current increased across the latter the potential difference fell, causing a further flow from the condenser. When this was discharged the current fell off in the arc, and the cycle of operations was repeated. A carbon arc in air appeared to require a large capacity, and hence there was a limit to the frequency produced. With the carbon-copper arc in coal-gas, the characteristic, as shown in Fig. 5, was much steeper, and then much less capacity was needed. In the apparatus on the table the potential difference across the arc was 200 volts, but 1,200 to 1,500 volts were reached in the condenser, and some 60 to 70 per cent of the total energy involved was obtained in the form of the alternating current, which might have a frequency of one million per second.

As regarded the application of the system to wireless telegraphy, its announcement had been hailed as the death-knell of the spark-gap; but it was always a risky proceeding to issue an obituary notice of an invention prior to its actual decease. The Poulsen system was not free from drawbacks. It was much more complicated, and involved the use of coal-gas, means of keeping the carbon in rotation, and of preserving its exact distance from the copper electrode. Skilled attention was required, and it was very difficult to maintain it in continuous work for more than a quarter of an hour. Further, it was difficult to work it with either a small or a large amount of power.

An ordinary 10-inch coil, with which spark-telegraphy could be effected up to a distance of 100 miles, took but one-fifth of a horse-power, while the Poulsen arc could not be well worked with less than 1½ horse-power. Again, 100 horse-power could be applied to the working of spark-telegraphy, while this could only be done on the Poulsen system by arranging a number of arcs in series, which presented great difficulties. Mr. Marconi had, however, recently devised a purely mechanical method by which the energy from a continuous-current dynamo could be transformed into high-frequency alternations. Owing to pending foreign patents, he could not, he regretted to say, describe the system in detail that evening, but he hoped that Mr. Marconi would do so himself ere long.

Prof. Fleming next proceeded to consider several types of detector for electric oscillations, taking first the electrolytic detector of Fessenden. This consisted, he stated, of a very fine platinum point dipping for about 1 millimeter into an electrolyte of weak sulphuric acid, and acting as one electrode of an electrolytic cell. The other electrode was a plate of silver, see Fig. 6, and the apparatus when employed as a detector was arranged as indicated in Fig. 7. The platinum electrode became polarized by means of oxygen, but if an electric oscillation was induced in the circuit, this polarization was dispersed and the current through the cell momentarily increased, thus causing a sound in the telephone. The detector, it should be noted, acted not merely qualitatively, but quantitatively, and it had therefore been possible to apply it to wireless telephony. The apparatus for this was, he continued, represented in Fig. 8, and consisted of a Poulsen arc coupled up with an antenna, the transformer of which was short-circuited by a microphone, as indicated. The latter, when spoken into, varied the strength of the waves, but not their length, and hence a current of varying intensity was passed through the electrolytic detector, coupled to the receiving antenna. Speech had with the apparatus been maintained over a distance of 16 miles, and it would be quite possible to speak across the channel.

Another form of detector which also had the property of being a quantitative instrument had, Prof. Fleming said, been introduced by himself some years ago. It consisted, as indicated in Fig. 9, of a glow-lamp, the filament of which was surrounded by a cylinder of nickel. When the filament was hot, negative electricity could pass from the filament to the nickel cylinder, but not in the reverse direction, and the instrument therefore acted as an oscillation valve. When submitted to the action of electric waves the current between the filament and the cylinder was rectified; as all oscillations in one direction were filtered out, this unidirectional current would deflect a galvanometer. The sensitiveness of the device had nothing to do with the size of the filament, and he had himself used in some cases 12-volt lamps and in others 4-volt ones.

Hitherto the antennæ used had been upright wires, which corresponded to Hertzian oscillators half buried in the ground; but, as Fitzgerald had shown, a closed circuit, if the frequency were very high, also acted as an oscillator. This Prof. Fleming demonstrated by using two square coils, in one of which a high-frequency current was set up, while the other was connected to a galvanometer through one of the oscillation valves just described. The coils being in tune, this galvanometer showed a deflection which, it was stated, was not due to Faradaic induction, but to electric waves. Here, then, he continued, was a new system of wireless telegraphy based upon the Fitzgerald oscillator, as Marconi's was on that of Hertz; and this new system was, he thought, capable of considerable development. If the oscillation valve was not fitted, the galvanometer showed no deflection, since it was affected by continuous current only. The efficiency of this oscillation valve depended much on the intensity of the incandescence of the filament.

The objection had been raised to wireless telegraphy, he said, that there was no privacy in the matter, as the waves spread out in all directions, affecting all instruments within range. A little progress had, however, been made lately in giving the waves a definite direction. About a year or so ago Mr. Marconi found that if the antenna was bent horizontally, as indicated in Fig. 10, the waves were more intense in the direction opposed to that of the horizontal limb, and that a receiver similarly bent was most sensitive to waves reaching it from the corresponding direction. Such an antenna radiated better on one side than on the other, but there was still a considerable radiation in every direction. By bending down the antenna, as represented in Fig. 11, the proportion of radiation in the one direction could be increased; and by using three wires arranged so that the waves produced interfered with each other in certain directions, Prof. Braun, of Strasburg, had succeeded in keeping the radiation almost wholly on one side of the transmitter. Mr. Marconi had shown that these bent antennæ could be used for the purpose of locating a ship. A number of these were arranged round a receiver, and by coupling this to each in turn the direction of the ship would be given by the antennæ, which showed the strongest indica-

tions on the detector. By means of two such stations some miles apart the distance of the vessel could also be approximately determined.

In conclusion, Prof. Fleming pointed out that although much work had been done, large districts of research were still incompletely explored. The variable transparency of the atmosphere to these waves was, for instance, not yet fully explained. Very long transmissions were dependent, not only on special skill in devising the apparatus used, but also on the condition of the atmosphere. Sunlight, for instance, had been found prejudicial to the transmission of these waves. It was now known that there were numerous positive and negative ions in the atmosphere. These, when a wave passed, were moved by it, absorbing energy, so that an atmosphere charged with ions corresponded to a slightly turbid medium. —Engineering.

THE TELESCOPE.*

ITS GENESIS AND ITS ACHIEVEMENTS.

BY D. B. MARSH.

THE telescope is undoubtedly the most important of all astronomical instruments. It has given almost a new sense to the human race, whereby many of Nature's greatest mysteries have been revealed, and it is the instrument to which is attached the numerous recent devices, such as the camera and the spectroscope, which have so greatly aided in the study of celestial physics.

The exact date of the invention of the telescope and the inventor's name are not known. It was probably used in Northern Europe prior to 1609. In a casual way, Galileo learned of an instrument constructed with a large double-convex lens in combination with a smaller double-concave lens, placed in a lead tube, and so arranged that far-away objects were distinctly observed.

Though Galileo was unable to see one, he soon wrought out the principle and constructed a telescope which magnified three times. This was shortly superseded by one magnifying eight times and so encouraged was he by this instrument that he soon constructed one magnifying thirty times. This was a great success, and many discoveries were made by it—lunar mountains were seen for the first time, spots on the sun were observed, the planet Venus was shown to have phases similar to our moon; Jupiter was found to have moons, and Saturn to have strange appendages, and the Milky Way was shown to be composed of myriads of stars.

The Galilean telescope was a wonderful instrument in its day, but it was soon to be surpassed. In 1637 Kepler suggested a telescope with two convex lenses in combination. The larger lens, as in Galileo's telescope, was placed toward the object to be viewed, but the smaller lens, instead of being concave on both sides and placed inside the focus of the large lens, was a double-convex lens and was placed beyond the focus of the objective or large lens. This smaller lens was held near the eye, and was called the eye-piece.

After considerable experimenting, it was found that a comparatively small objective, with a long focus, was the most satisfactory. In 1672, Campani, of Bologna, constructed an instrument of this kind 136 feet long. Huygens made one 123 feet long, which he presented to the Royal Society of London, while Auzout had one constructed 600 feet in length, but it was too unwieldy. These telescopes, notwithstanding their great length, were far from perfect, as they were affected by both chromatic and spherical aberration. Newton believed it impossible to correct the chromatic defect, and in deference to the great philosopher's judgment, no one for some time seriously attempted the task. However, in 1758, an English optician named Dollond proved Newton wrong. On carefully examining various kinds of glass he observed that some specimens had greater dispersive power, and it occurred to him to make a telescope objective combining two different kinds of glass. He found that by combining a convex lens of crown glass, which has the least dispersive power, with a concave lens of flint glass an image could be formed with almost no chromatic defect.

This was another great step in the construction of telescopes, for with a 3-inch objective and a focus of only 45 inches, a magnifying power of 200 could be had. It is interesting to note that, owing to the difficulty of procuring optical glass, Dollond never constructed a telescope larger than 4 inches in diameter.

Between 1830 and 1860 the manufacture of optical glass was much improved, and lenses were made as large as 12 and 14 inches in diameter. In 1861, one 18 inches in diameter was made for the Dearborn Observatory at Evanston, Illinois. In 1871, this was surpassed by one of 26 inches aperture made for the U. S. Naval Observatory at Washington, D. C. These splendid objectives were made by Alvan Clark, of Cambridgeport, Mass., whose firm indeed has constructed some of the largest in the world—that of the Lick telescope, 36 inches in diameter, and the Yerkes, 40 inches in diameter. The lens of the Lick telescope, in its cell, weighs about 700 pounds and cost $53,000. The focal length is 56 feet. The Yerkes objective weighs half a ton and cost $65,000.

So far I have been speaking of refracting telescopes only. Let me ask your attention briefly to reflecting telescopes. These are of three kinds—the Gregorian, the Cassegrainian, and the Newtonian. Philosophers believing it impossible to overcome the unequal refrangibility of the different colored rays of light, gave up the idea of perfecting the refracting telescope, and directed their attention to constructing an instrument on a different principle, using a concave mirror to form the image of the object observed. Mersenne, in 1639, suggested the employment of a spherical mirror, but the idea appears to have been dropped. Quite independently Gregory, in 1663, proposed a similar arrangement, using however a parabolic in place of a spherical mirror. He endeavored to find a workman able to construct such, but could not at that time.

In the Gregorian instruments the parabolic reflector is placed at the lower end of the tube, while on its axis and a short distance beyond its focus, is placed a small concave reflector. The light from the distant object falls upon the large mirror, from which it is reflected back to the small one, which throws it back through a hole in the center of the large reflector. It then passes into the eyepiece, which indeed in Gregory's time had been much improved by Huygens.

Gregory's efforts along this line turned Newton's attention to reflecting telescopes, and he set to work experimenting on an alloy suitable for a speculum. In 1669, he cast his first disk and began to grind it, but it was not until 1672 that he had real success. Then he made two small instruments, one of which was only about an inch in diameter, with a magnifying power of about 38.

The principle of Newton's telescope differed from Gregory's in that it had a small plane mirror placed in the cone of light from the reflector, at an angle of 45 degrees. Being placed inside the focus, this mirror turned the light cone at right angles to its original direction, thus forming the image outside the tube, and obviating the necessity of a hole in the parabolic reflector.

About the same time that Newton completed his instrument, the Cassegrain construction was proposed. This was the same as the Gregorian telescope except for the small mirror. In the Gregorian this mirror was concave, while Cassegrain proposed a convex mirror, to be placed inside the focus. It brings the light from the object to a focus through a hole in the center of the large parabolic mirror.

The largest Cassegrainian telescope in use to-day is in the Melbourne Observatory, erected in 1870. It has an aperture of four feet, and is used in observing and photographing the nebulæ and star-clusters in the southern hemisphere.

Owing to the difficulty in obtaining a suitable alloy, little progress was made for some time in constructing reflecting telescopes. In 1718, however, Hadley, the inventor of the sextant, constructed one on the Newtonian principle, 5 feet in length. The instrument magnified over 200 times, and it revealed as much as the old refracting telescopes. Perfect as this Newtonian telescope seemed to be, the Gregorian type held the field until 1774.

By using a small Gregorian telescope, Herschel had his attention directed to the wonders of astronomy, but his income being too limited to purchase an instrument he set about making one for himself. During his life, he is said to have made upward of 400 telescopes, mostly of the Newtonian type. Among his earliest efforts was the construction of a 5-foot reflector which was a grand success. Then came one 7 feet in length. The largest of his instruments was completed under George III. in 1789. This telescope surpassed all previous efforts, as it was actually 40 feet long, and had a reflecting mirror 4 feet in diameter. The story of Herschel's work with this great telescope would fill a volume.

One of the best specimens of the Newtonian reflector was produced by Mr. Lassell, of Liverpool, England. With it two satellites of Uranus, a satellite of Saturn, and the single satellite of Neptune were discovered. This instrument is now in the Royal Observatory of Greenwich.

The largest telescope of the reflecting type was constructed by Lord Rosse, an Irish peer. It has a diameter of 6 feet, but it can be used only for observations on or near the meridian. At the present time both refracting and reflecting telescopes are in use, and are brought to a great degree of perfection. Just which is better, it would be hard to say. It depends largely on the requirements of the observer. The old speculum metal reflector has been almost discarded, and glass, coated with silver, has been substituted. The glass is much superior to the metal, as it can be figured more accurately, and if tarnished the silver can be renewed without changing the figure of the mirror.

For observing nebulæ and star clusters, perhaps the reflecting telescope is to be preferred, provided the mountings are suitable. The silvered mirror can be made to reflect 90 per cent of the light it receives. The refracting telescope is much more convenient to manipulate, and requires much less attention. The lenses are so perfectly made that the chromatic and spherical aberrations are reduced to a minimum, so far as visual observation is concerned. For photographic purposes, an extra lens is sometimes placed before the visual objective, which suitably corrects for the rays effective in photography. This is done on the 36-inch Lick, and the 40-inch Yerkes. In some cases the light passes through colored screens which allow to pass only those rays for which the telescope is corrected. Taylor, of the firm of Cooke & Sons, has devised a "triple" objective, which, it is claimed, is suitable for both visual and photographic work without the use of screens.

Lastly, let me refer to the horizontal telescope. In this case the telescope is rigidly fixed along the ground and the light from the heavenly body is reflected into it by a perfectly plane mirror moved by clockwork.

* Journal of the Royal Astronomical Society of Canada.

CAUSES OF THE QUALITY STRENGTH IN WHEATEN FLOUR.

By A. E. HUMPHRIES.

SPEAKING before the British Association at Leicester, England, A. E. Humphries said that the Home-grown Wheat Committee of the National Association of British and Irish Millers has for several years been engaged in producing wheats in England which shall yield maximum crops of grain and straw, the wheat to be equal in strength, and therefore in commercial value, to the best imported varieties.

The field of inquiry has been a wide one, and among other things the committee has sought to ascertain "the ultimate cause of strength in wheat, the nature and source of those constituents which confer on some varieties of wheat the inherent quality of strength, and the power of transmitting it to succeeding generations." It has been proved that though climate and soil influence quality they are not the determining factors in the production of strength, for though the strongest wheats are ordinarily produced in districts where the winters are cold, the summers hot, and the summer rainfall high, certain varieties possess and retain the inherent quality of strength when grown in England. Manuring or early cutting at harvest time has no beneficial effect on quality. Quick growth or rapid maturation is not correlated with strength nor does the percentage of natural moisture in well-harvested wheat indicate it; indeed, in certain cases the addition of water to wheat materially increases its effective baking strength.

The term "strength" has been loosely applied to cover several characteristics. It should not be measured by the quantity of water required to make doughs of a standard consistency, nor by the quantity of bread produced per sack of flour used, nor by the way a flour behaves in the dough, but by its capacity for making big, shapely, and therefore well aerated loaves. This definition covers two characteristics; one, a flour's capacity for making gas in yeast fermentation; the other, its capacity when made into dough for retaining the gas so generated.

The gas-making power will depend largely on the percentage of natural sugar any given wheat contains and its diastatic capacity. These characteristics vary substantially in different wheats. The baker can, and does, influence the quantity of gas generated in baking. The retention of gas when made involves complex problems.

The percentages of total nitrogen, gluten, gliadin, and amyloids do not correctly indicate the relative strengths of various flours. The theory that strength depends on a correct ratio between gliadin and glutenin is untenable. Prof. Wood's suggestion that the gas-retaining power of a dough depends on its ratio of

protein to salts is worthy of the closest attention in view of the fact that the physical, as distinct from the chemical, properties of proteins are profoundly affected by small quantities of acids, alkalis, and salts. —Chemical News.

ENGINEERING NOTES.

Chrome steel drop forgings are used to a considerable extent abroad, in automobile parts. Their high resilience makes them almost necessary for certain parts, even though they are expensive and difficult to machine. Their appearance indicates that they are formed in cast dies, for while their dimensions are fairly accurate, they do not have the smooth finish of softer work struck with machined dies. Experiments with chrome steel in this country, using the best hardened machined dies, have resulted in the rapid destruction of the dies. The German manufacturer makes a pattern from the drawing, and from this pattern casts steel dies of a special composition. The business of making these dies involves a high degree of skill in the making of steel castings, a considerable knowledge of the possibilities of the various compositions of steel, and requires a complete foundry apparatus.—Iron Age.

The cost of anthracite coal is, according to The Engineering Record, bound to rise steadily; not on account of any combination of producers, but from growing cost of production. The paper gives a few facts based on the experience at a colliery at Pittston, Pa., which are worth considering in connection with this subject. The shaft reached a coal seam 10 to 12 feet thick at a depth of 175 feet, and here coal could be taken out at the rate of 15 tons per miner per day. After this seam was worked out, the shaft was carried down to a second, about 6 feet thick; then to a third, about 6 feet thick, and finally to a fourth, only 3 feet 10 inches thick and 270 feet below the surface, where one miner can produce but 5 tons per day. Under the present conditions it is necessary to employ three times as many miners to get out the same amount of coal as originally, and also a much larger number of timber men, drivers, runners, and masons. It has been necessary to more than double the ventilating equipment and to increase many times the force of men employed in keeping the ventilating system in working condition. The amount of water to be removed has increased from 300 to 3,500 gallons per minute. The wages of the miners have been raised and they are now paid for both coal and rock removed, while formerly they were paid solely for the coal. This list of increased expenses could be made much longer, but enough has been stated to indicate why the working of the anthracite fields is more expensive now than formerly.

An interesting new railroad is projected between Switzerland and Italy. It will commence in Switzerland at a point not far from the frontier and pass through the Splügen tunnel, which is to be constructed, and come out upon Italian territory, after the manner of the Simplon. Dr. Locher-Freuler has drawn up the present project. According to this, the railroad will start from the station of Coire lying upon the Federal Railroad, and then pass along another line known as the Rhetic Railroad, reaching Ems, where a new railroad station will be built. From Ems the new line will diverge from the former and then pass the Vogelsang in tunnel. After crossing the Rhine, it will follow the left bank as far as Rothenbrünnen where a depot will be erected. Passing thence by the stations of Thusis and Rongellen-Zillis it will enter the Splügen tunnel. The tunnel itself will be an important piece of engineering work, and is to be no less than 16 miles long. About half of it will lie on each side of the frontier, and it rises in an easy grade up to the culminating point, which is about the center of the tunnel. This arrangement, which resembles the plan adopted for the Simplon, will give proper drainage. A single track will be used within the tunnel, with three crossing points at which stations will be located, and here the track will be double for a length of 1,500 feet. About eight years will be necessary for this work. As in the Simplon tunnel, it is proposed to construct a first tunnel at present, and at the same time to take the necessary measure for building a second tunnel parallel to the former at a later period. Coming out of the tunnel upon the Italian side, the road will pass by Cailivaggis and two other stations, and end at Chiavenna. This latter point is located upon the already-existing line of electric railroad which was built several years ago and is under the control of the Italian government. It runs from Chiavenna to Colico and Lecco and then joins on to the steam railroad which passes to Milan and Genoa, connecting also with the Bergamo-Venice railroad line. According to the present project, most of the line with the exception of a short section near the starting point will be operated by electric traction, using electric locomotives for the through traffic and perhaps a type of motor car for the local service. Concessions have been already secured for the hydro-electric plant which will be needed to furnish the current.

ELECTRICAL NOTES.

A curious effect of leakage from the negative cable of an electric tramway in Liverpool has been investigated by Dr. Bassett. The leakage was discovered through horses receiving shocks when passing over the place, and, when the ground was opened it was found that the top of the wooden trough carrying the cable had been burned through, while a hard alkaline material had penetrated the hole and become so firmly incrusted on the wire that it had to be chipped off with a hammer and cold chisel. The fragments were of a dark gray color, and on treatment with water, emitted bubbles of hydrogen, which caught fire and burned with a lavender or yellow flame. This reaction pointed to the presence of free potassium or sodium, and, in fact, when the material was broken open, the interior crevices were found to contain a fluid alloy of the two metals. A quantitative analysis of the incrustation showed it to contain 33.27 per cent of potassium hydroxide, 32.26 per cent of sodium hydroxide, 1 per cent of metallic potassium, 0.8 per cent of metallic sodium, 4.83 per cent of soluble silica, 26.36 per cent of earthy matter, and 1.41 per cent of moisture and bitumen. Dr. Bassett came to the conclusion that the free alkali metals had first been formed by electrolysis from the potassium and sodium salts in the surface soil, for they were present in the same proportion as in the incrustation; and that the free potassium and sodium then reacted with water to form the respective alkali hydroxides with the evolution of hydrogen. Had there been accumulation of this hydrogen and subsequent admixture with air, a violent explosion might have taken place; and it is not improbable that a chemical process of this kind may account for some of the explosions that have occurred in the neighborhood of electric mains, the primary cause of which has usually been attributed to an accumulation of escaping coal gas.

Mr. W. J. Davis read a paper recently before the Chicago branch of the American Institute of Electrical Engineers, in which he gave some indication of the magnitude and direction of engineering development in apparatus for the electrical equipment of high-speed interurban railways. These systems are divided into three classes: (1) 600-volt direct-current, using either overhead trolley or third rail; (2) 1,200-volt direct-current, overhead trolley; (3) single-phase alternating-current, 3,300 or 6,600 volt, overhead trolley. From a table which is given in the paper, we gather that the length of track miles of each of the systems named is 188, 129, and 142 miles respectively. The total horse-power of the motors sold is 43,380, of which 600-volt direct-current has 33 per cent; 1,200-volt direct-current, 27 per cent; and single-phase alternating-current, 40 per cent. It is interesting to note that two-thirds of the total motor capacity sold consists of 1,200-volt direct-current and single-phase alternating-current motors. As to the relative merits of the three systems, these, of course, must depend upon local conditions, and each case must be specially investigated, so that in reading Mr. Davis's determination of the relative merits one must bear this in mind. Mr. Davis holds that (1) street railways and elevated roads in cities should unquestionably be equipped with standard 600-volt direct-current apparatus. (2) suburban lines 10 to 15 miles in length, operating cars on frequent headway, should be equipped with 600-volt direct-current system; (3) for high-speed interurban railways operating cars 50 feet or more over all at speeds of 40 miles an hour or more—(*a*) the 600-volt direct-current system is the most reliable on account of being most fully developed; (*b*) the 1,200-volt direct-current system is somewhat cheaper in cost than the 600-volt system, but is as yet an untried system; (*c*) the single-phase alternating-current system will in most cases show material saving in cost over the direct-current system, and has been developed to a point where it may be considered commercially successful and capable of giving satisfaction in operation, if properly proportioned for the service to be performed. He gives some interesting comparative costs of the equipment and operation of the various lines. On a typical suburban road (single track) the first cost of the various systems are given as follows: 600-volt direct-current, $27,470 per mile; 1,200-volt direct-current, $26,170 per mile; 6,600-volt alternating-current, $24,470 per mile. The relative operating costs per mile (single track) per annum: 600-volt direct-current, $740; 1,200-volt direct-current, $665; 6,600-volt alternating-current, $605. Another method of comparison is to capitalize the annual saving, exclusive of fixed charges. Mr. Davis assumes fifteen years as the average life of equipment and construction work, and at this rate the present value of the annual saving in operating expenses per mile of track at 5 per cent interest will be: for the 1,200-volt direct-current system, $755; to which add saving in first cost, $1,300 = 7.5 per cent, making total capital value of $2,055; for the 6,600-volt single-phase system, $1,390; to which add saving in first cost, $3,000 = 16 per cent, making total capital value of $4,390.

TRADE NOTES AND FORMULÆ.

Varnish from Rubber Waste.—A very durable varnish may be produced from old rubber waste as follows: Take 2 parts by weight of old rubber, 4 parts of rosin, 4 parts of linseed oil varnish, and 0.5 part of sulphur. Heat these ingredients in an iron kettle until they are evenly dissolved; after this, while it is still warm, add 4 parts by weight of American rectified oil of turpentine and then with about 10 to 12 parts of linseed oil varnish. The varnish may be colored as desired with earth colors, or left in the original color. Uncolored the varnish has a honey yellow tint, like a dark copal varnish. The varnish is recommended particularly for painting the lead covers in chloride of lime cells, and its power of resisting free chlorine has been amply tested. The varnish has an excellent gloss and, if good boiled oil has been used in making it, dries in a few days.

The Manufacture of Neats Foot Oil.—In a kettle, fresh ox, calves' or pigs' feet are boiled in water for a quarter of an hour, and then the temperature reduced, so that the fluid no longer bubbles up. The fat that collects on the surface of the water, in the form of an oily layer, is constantly removed with the aid of a shallow skimmer and collected in a tall, narrow vessel. The residue in the kettle, the feet, freed from fat, are turned over to the glue maker. Allowed to stand for a long time in the tall vessel, the neats foot oil collects in the form of a clear stratum, on the top of the water, and is removed and filled into small bottles, made of clear, white glass, which are tightly closed, and exposed to the direct rays of the sun in order to bleach the oil. According to R. Brunners' experience, the bleaching process is accelerated by allowing the light to reach the bottles through a piece of violet glass, the violet-colored rays having a more active effect. The finest product is that obtained by freezing. For this purpose, the neats foot oil is exposed to a severe winter's cold, and while in the cold condition, the fluid portion is separated from that which has become solid, by filtering it through fine linen. In France, sheep's feet are first cooked out for twenty minutes in water heated by steam to a temperature of 75 deg. to 80 deg. C. (167 deg. to 176 deg. F.), after which wool and hoofs are readily removed by hand; then the feet are boiled out with steam.

Silver-plating Processes and Recipes. (Abstracted from various European sources.)

Hints on Cleaning, etc., Silver.—Borax is a good silver preservative; dissolve soap and borax in hot water; immerse the objects, and rinse with clear water.

The luster of silver may be kept fresh by wrapping the article, after cleaning, in tinfoil.

A simple liquid purée of potatoes imparts brilliancy and perfectly cleans a silvered article; if an antique appearance is desired, rub the object with a skin soaked in petroleum.

Rubbing with soot cleans silver articles, and removes any reddish hue. To remove the soot, wash first with boiling and afterward with tepid water. Rub with a soft brush, then with a piece of flannel, and wipe with a fine cloth or leather.

A silvering powder is prepared by pulverizing and mixing equal parts by weight of alum, acid potassium oxalate, and cream of tartar. Moisten with water for use, and rub vigorously. Polish with a leather.

Glass may be silvered by reducing on its surface a silver salt by means of a mixture of ammonia and alcohol. Excellent telescopic mirrors are thus prepared.

Silvering on silk ribbons: Very beautiful effects may be obtained by drawing on silk ribbon with a new pen or fine brush, using a solution of nitrate of silver to which a little gum has been added to give it consistency. The drawing should be allowed to dry for a minute or two, and then placed over a vessel containing zinc, sulphuric acid, and water. The silver is reduced and adheres perfectly to the ribbon.

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